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## REPORT OF THE ENTOMOLOGIST

UNITED STATES DEPARTMENT OF AGRICULTURE,  
BUREAU OF ENTOMOLOGY,  
*Washington, D. C., September 10, 1924.*

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1924.

Respectfully,

L. O. HOWARD,  
*Entomologist and Chief of Bureau.*

HON. HENRY C. WALLACE,  
*Secretary of Agriculture.*

### DECIDUOUS FRUIT INSECT INVESTIGATIONS

Investigations of deciduous fruit insects have been carried out under direction of Dr. A. L. Quaintance as formerly.

#### JAPANESE BEETLE

Owing to increased appropriations, the work on this pest has been materially strengthened, especially the inspection of farm products and nursery stock; research activities have been broadened, and new investigations have been undertaken. Several lines of inquiry have been completed and reports prepared, or are in course of preparation.

Two years' intensive study to determine whether refrigerating soil balls about the roots of conifer plants would be effective in destroying the larvæ showed that in general when plants were subjected to low temperatures the grubs were destroyed in the soil ball, but in the case of most of the plants treated the margin of safety was so small between the temperature which would kill the grub and one which would injure the plant that this method of treatment is of doubtful value from the commercial standpoint. It was found that the larvæ could withstand very low temperatures, approaching zero in many cases, provided the changes in temperature were not sudden. On the other hand, lowering the temperature

30 or 40 degrees within 8 to 12 hours would in most cases give 100 per cent kill.

In view of the danger of distributing the grubs in soil around the roots of evergreens, extensive experiments were undertaken in the removal of the soil balls from conifer trees and then remaking the ball with uninfested soil. It was found that in the case of evergreen stock up to 6 or 7 feet in height, the soil could all be removed, the roots washed, puddled in clay, and repacked in uninfested soil, with an average loss of not more than 10 per cent greater than the average loss which occurs in transplanting the trees from one situation to another, as ordinarily practiced. With certain plants this loss is very much less; in fact the data accumulated indicate that it was very little greater than the loss occurring through ordinary transplanting; on the other hand, some less hardy species, as varieties of *Retinospora*, suffer a much greater loss from the removal of the soil ball. The cost of remaking the soil ball with uninfested soil, added to the average loss from transplanting, is equivalent to about 13 cents per tree. These tests, it is believed, point out a way of utilizing evergreen stock grown in infested regions, which otherwise might become a total loss.

A study of the effect of the more common cultural practices and the effect of different methods of fertilization upon the larvæ of the Japanese

beetle indicates that when this work is done in late fall and early spring, from 40 to 50 per cent of the larvæ may be destroyed. Experiments also indicate that by a number of cultivations during the egg-laying season of the beetles 25 to 30 per cent of the eggs will be destroyed. Experiments have been made to determine methods of treating the soil about the roots of rhododendrons, blueberries, azaleas, etc., which normally grow in heavy mixtures of peat and sand. It was ascertained that proper treatment with carbon disulphide will kill about 100 per cent of the larvæ. A large number of organic compounds were carefully compared in efficiency and availability with carbon disulphide as soil insecticides, but none of them proved to be superior.

Especial attention has been given to life-history studies and ecological investigations, including the physiology of the insect in all its stages, with special reference to environmental conditions. The object in view is to determine the probable future distribution of the insect and its reaction toward new environments when it reaches such regions as the corn-growing belt in the Middle West, the cotton region in the South, and the fruit regions in the North. Chemo-tropic studies with the adult beetle have been continued, and it was found that certain essential oils when sprayed on the foliage or mixed with bran and used as a bait were decidedly attractive to the beetles. Geraniol appears to be the most attractive of those tried. It is hoped that further investigations of this kind will be well worth while.

Substantial progress has been made with the study of the effect of insecticides on the beetles. The recommendation of 4 pounds of arsenate of lead to 50 gallons of water with the addition of 2 pounds of flour as a spreader, made last year, has been reduced to 3 pounds of the poison to 50 gallons of water. The relative kill resulting from the use of this material, however, is not high, probably not over 15 or 20 per cent on the average. On the other hand fairly good protection has been secured to both fruit and foliage from the repellent action of the spray. A process has been devised of coating the particles of arsenate of lead with an insoluble soap, such as lead oleate. This work has necessitated a large amount of experimentation, involving some 96 different soaps. It was found that a mixture of arsenate of lead paste con-

taining 2 per cent of lead oleate on the basis of dry weight gave the most perfect mixture from the standpoint of spreading and sticking to the foliage. Cage experiments carried out during the latter part of the summer of 1923 indicated that the beetles feed readily on leaves sprayed with this mixture. Definite control experiments in apple, peach, and cherry orchards, and vineyards, have been carried out to determine the amount of killing of the beetles which may be expected when spraying is carefully and systematically done.

Distinct progress has also been made in the study of insecticides for the destruction of grubs in the soil. Experiments have been continued on conifer nursery stock which is normally shipped with soil about the roots. A method of treating this soil while the trees are standing in the row has been developed, namely, the use of carbon disulphide applied in a dilute solution with a large quantity of water. It has been possible to obtain a kill of the grubs 24 inches below the surface. This treatment has been applied both in the fall and spring without plant injury. Further work, however, must be done to verify these preliminary results before this method can be put into commercial use.

Another method is the fumigation of the soil ball around the roots of conifer stock with carbon disulphide gas. In this treatment the tree is inverted in a tank of water to protect the top from the effects of the gas, while the roots and soil ball are exposed to the vapor of the chemical for from 6 to 12 hours. There has been no difficulty thus far in killing the grubs, and the plants have shown little injury.

Experiments have been completed on the treatment of soil in coldframes or in nursery beds to destroy the grubs. This method requires the addition of acid lead arsenate to the soil at the rate of 1,500 pounds to the acre. It has been found that the arsenate of lead undergoes certain chemical changes after being mixed with soil and has a tendency to form basic arsenates. Methods are being studied of treating the lead in such a manner as to protect it from the action of the soil and soil organisms so that it will remain in the acid condition. The use of poisons, such as arsenate of lead, in the soil to destroy the larvæ of the beetle, it is believed will have a much wider application than merely the treatment

of soil in and about nurseries. Experiments are under way to ascertain the value of such treatment in the destruction of grubs in golf greens without injury to the sod. It has also been determined that carbon disulphide emulsion is a satisfactory treatment for sod lands, golf courses, and the like to free them from grubs, and this material has already come into use on certain golf courses in the infested region.

Every effort has been made to secure the maximum number of parasitic enemies of the Japanese beetle, and to surround them with every condition which will add to the likelihood of their establishment. Seven thousand or more adults of a tachinid, *Centeter cinerea*, were released during 1923. Several days after this colony was released numerous beetles were collected in the field bearing fertile eggs of this parasite. The parasitized beetles were kept out of doors throughout the winter and the adult flies emerged from them in June, 1924. Later examinations in the field showed that many beetles had been parasitized by flies which issued under natural conditions in the field. Beetles bearing the eggs of *Centeter* have been recovered at distances of 3 to 4 miles in each direction from the point where the flies were liberated. Throughout this area of 15 to 16 square miles, parasitized beetles were fairly common during the summer of 1924. Several hundred adult dextids (*Prosenia siberata*) were released in 1923, but down to date there have been no recoveries. The insect, however, is quite difficult to find, and it is not improbable that it may turn up even after a year or two. It is planned to release several thousand adults of the *Prosenia* parasite during the summer of 1924, from Japanese material.

Studies of the fungous and bacterial diseases of the Japanese beetle have been pushed as much as possible. Several distinct species of bacteria have been isolated which apparently cause specific diseases when inoculated into the larvæ. Twenty-nine different cultures of bacteria were distributed in field plots in the autumn of 1923, but it is impossible to determine the effect. A culture of *Isaria densa* obtained from France was disseminated in the field in 1923, and recoveries of this fungus have already been made from grubs collected in the spring of 1924. The percentage of grubs attacked, however, is small; but as the fungus becomes more widely distributed its value will, it is hoped, increase.

In cooperation with the States of New Jersey and Pennsylvania and with the Federal Horticultural Board, the prevention of spread of the Japanese beetle has been enforced to the fullest extent possible with the funds available. A revision of Quarantine Regulations 48, effective April 15, 1923, brought the city of Philadelphia within the infested area and has rendered the quarantine enforcement a much more complicated problem. During the summer of 1923 the inspection included corn, cabbage, lettuce, and grapes, which were inspected on the farm before shipment. Several hundred thousand baskets of corn were inspected during the summer of 1923 and many thousands of beetles removed from the corn before it was certified for shipment. The inspection of nursery, ornamental, and greenhouse products, soil, compost, and manure was carried on throughout the year.

Scouting to determine the limits of infestation has also been prosecuted, and it was found by the close of the season 1923 that the beetles had spread over a territory of some 2,500 square miles. During the summer of 1923 the beetles spread rapidly across the pine barrens of central New Jersey and reached the Atlantic coast, a movement which was undoubtedly facilitated by the large amount of automobile traffic moving in that direction. The spread of the beetle westward in Pennsylvania, representing an extension of area of 15 or 20 miles, was about what was expected, owing to the flight of the insect, which can not be prevented.

Owing to increase in the infested area and also to the fact that the city of Philadelphia was included in the **quarantined area**, the method of carrying out the farm-products quarantine was changed from one of inspection of products at point of origin, or where grown, to the zone system. Using the city of Philadelphia markets as a center, a zone was established within a radius of approximately 25 miles. It is probable that fully 90 per cent of the restricted farm products originating within the beetle-infested territory and coming to the Philadelphia markets is consumed in this zone. All products originating within the infested area and sent to Philadelphia markets were allowed unrestricted movement within this zone. Farm produce moving from the infested area to more distant points, as New York, Atlantic City, etc., was inspected and certified at point of origin and shipped

direct to its destination. State and Federal quarantines restricted the movement of produce from Philadelphia to points outside of the zone. The zone system worked satisfactorily during the season of 1923.

However, it was found that when an unrestricted movement of farm products was permitted from the infested area to the Philadelphia market, thousands of beetles were carried to the market daily in corn and other produce. In the market district the nature of the commission business renders it impossible to segregate produce originating from various points. It is thus possible for most kinds of produce emanating from the Philadelphia market to become infested with the beetle. Inspectors' reports made during the summer of 1923 showed that the beetles were to be found in gutters and streets feeding on garbage as well as on produce inside of the stores and on the pavements in the market. Beetles were collected in baskets, crates, and other containers of potatoes, oranges, elderberries, etc.

In view of the impossibility of satisfactory inspection and certification of produce originating in the Philadelphia markets, it was necessary to establish an embargo, effective from June 15 to October 15, on a very large class of produce likely to be moved. The enforcement of the embargo is being carried out by placing inspectors on all important roads leading out of the Japanese beetle area at points near the boundary. Provision is also made for the inspection of certain produce shipped by railroad freight and which is permitted to move after inspection and certification.

Philadelphia represents the center of one of the largest nursery and greenhouse districts in the United States and nearly all types of nursery business are represented in this region. There are in the area now under quarantine approximately 1,500 nurseries and growers of ornamental plants. Approximately half of the nursery stock grown in the restricted area consists of evergreens. Large quantities of outside-grown perennials, such as phlox, iris, dahlia, peony, etc., are propagated and shipped from the quarantined zone. In view of the great danger of distributing the insect over long distances by means of nursery stock, especial attention has been given to this phase of the work, and so far as known the long-distance spread of the beetle has thus far been prevented.

#### GRAPE INSECTS

Investigations of grape insects in co-operation with the Ohio Agricultural Experiment Station, with headquarters at Sandusky, have been continued as during last year. Especial attention has been given to the grape leafhoppers, which continue to be the most abundant and destructive insects attacking the grape in that district at the present time. Particular attention has been given to tests of equipment for more thorough and rapid applications of spray mixtures. It has been found that a converging spray is most effective. Numerous types of spray booms designed for leafhopper control have been tested and boom attachments developed which show more satisfactory results than by trailer or hand-nozzle spraying, and the labor expense is much less. Few eggs of leafhoppers hatch from leaves which have been covered on the lower surface with spray mixtures containing 40 per cent nicotine sulphate at a strength of 1 to 1,200, and the number of eggs destroyed was apparently in proportion to the amount of covering secured by the spray solution. To be effective, applications must be made with great thoroughness. Tests made indicate that nicotine sprays should be applied somewhat earlier than heretofore.

Further observations have been made on the possibility of using nicotine dust in the control of the grape leafhopper. Results in general compare favorably with the results obtained with liquid applications of nicotine, especially if the dusting machine is followed by a spring-tooth harrow, which buries many of the nymphs that have fallen to the ground from the effects of the dust.

Critical life-history studies of the grape leafhoppers have been continued and are now practically completed. They include a physiological comparison between species, correlated with structural and ecological characteristics. Attention is also being given to other grape insects, as the grape-berry moth and the rose-chaffer.

#### NUT INSECTS

Studies of nut insects have been continued, as previously reported, at French Creek, W. Va., at Thomasville, Ga., and at Brownwood, Tex. At the French Creek station, life-history studies have been completed of several of the nut weevils, and preliminary experiments carried out with control measures. These studies include the



larger and lesser chestnut weevils and hazelnut weevil. Experiments in spraying chestnuts for the control of the chestnut weevil have been carried out in cooperation with the Bureau of Plant Industry at the department's chestnut orchard at Bell Station, Md. This work has not proceeded far enough to permit conclusions. Biologic studies of the hickory twig-girdler have also been given special attention in view of the serious injury which this insect has occasioned in the Carolinas and Virginia. Experimental control work in nurseries at Petersburg has also been carried out.

Among pecan insects, the pecan nut case-bearer has received special attention. Knowledge of its life history has been pretty well rounded up. Many experiments with arsenical sprays have been carried out in pecan groves to determine their value when applied at different times and at different dosages. The control of the insect is considerably complicated on account of the sensitiveness of the pecan to arsenical sprays. Experiments were also carried out in the testing of various other materials, such as oil emulsions, for possible use on trees while still dormant. No very satisfactory results have been obtained. The pecan weevil, which is quite injurious locally, has been the subject of careful study both from the biologic and control standpoints. Preliminary results indicate that the beetles can be killed by arsenicals while on the trees during August and September. The larvae or grubs in the nuts, it has been found, will succumb to proper dosages of carbon disulphide. A goodly number of parasites of the insects attacking pecan have been studied from time to time as opportunity offered, and it is possible that some means may be found of encouraging them.

#### PEACH INSECTS

The third year's work on the biology of the plum curculio was completed during the fiscal year 1924 at the Fort Valley, Ga., laboratory, maintained in cooperation with the Bureau of Plant Industry and the Georgia State Board of Entomology. It was found that only one generation of this insect occurred in Georgia in 1923, whereas during the preceding two years two generations each season were found. This difference is thought to have been due to the late spring of 1923, which delayed overwintering beetles in leaving hibernation and prolonged the pupal stage in the soil. Results of

four consecutive seasons' life-history studies in Georgia will be brought together at the close of 1924 and will form the basis of an unusually complete report on this important peach pest.

Peach spraying and dusting experiments were carried out in orchards in cooperation with growers, as heretofore. This work substantiated conclusions announced in Department Circular 216. Work to determine the possibility of after-harvest control of the plum curculio was concluded during the year and the results published in Department Bulletin 1205. In connection with these curculio studies, much assistance has been rendered orchardists by advising them of the proper spraying and dusting materials, dates of application, etc., according to varying weather conditions. A method of curculio control long recognized as of value, but which appears never to have been demonstrated experimentally, is the picking up of infested dropped fruits. This investigation, under way for some seasons, has shown conclusively the great value of this procedure, especially during years of unusual abundance. It approximates in importance the use of arsenical sprays.

Further studies of paradichlorobenzene for peach borer control, especially the use of the chemical on young trees, have been made. It appears that the material can safely be used on trees 4 years of age and over.

#### SAN JOSE SCALE

Experiments with the use of lubricating-oil emulsions for the control of this and other scale insects have been carried on at several of the field stations. At the Bentonville, Ark., laboratory, where this emulsion was first extensively tried out, the results of previous years as to its efficacy have been confirmed. A very large amount of the emulsion has been used in this section, and the serious infestation of the scale on apple of a few years ago has been brought under complete control. There has also been an important saving in the fruit-growers' spray bill by the use of this preparation as against other scale washes, such as lime-sulphur.

At the Yakima, Wash., laboratory experiments with the oil emulsion indicate that when used at 3 per cent strength it is satisfactory in killing the winter eggs of the European red mite and other mites. Under Pacific Northwest conditions a 3 per cent emulsion is also necessary for the effective control of the San Jose scale.

An emulsion made with casein has been found to be practically as effective as other types and is somewhat simpler to handle. Such emulsions are more stable when mixed with the hard waters generally used in that section in spraying operations. A miscible oil made from a light lubricating oil has been developed which will be useful to orchardists under some conditions. The method of preparation involved is essentially that employed by various manufacturers of miscible oils.

At the Fort Valley, Ga., laboratory the workers tried to find whether the 2 per cent emulsion would be effective in the control of the San Jose scale on peach and not injure the trees. Extensive tests have now been made over a two-year period with most excellent results in killing the insects and without producing any injury to trees. This spray has come into much favor with the peach growers in Georgia since it is less disagreeable to use than lime-sulphur and is more effective and cheaper than other dormant sprays.

The oil emulsion is also being tested for the San Jose scale on various plants at the Vincennes, Ind., laboratory, in cooperation with the Purdue University Agricultural Experiment Station. It has been found that a wide range of oils give good results. No injury to trees has resulted, except to a limited extent with some improperly prepared emulsions. Further experiments during summer indicate that every effort should be made to effect treatments during the dormant season, since the oil on foliage results in some spotting of the fruit and some injury to the leaves. Incidentally it was observed that such trees, when dusted later, held the dust to a remarkable extent. Summer spraying of peach with the emulsion is unsafe.

#### CODLING MOTH

This insect, while not receiving the former amount of attention at field stations, has been nevertheless the subject of some experimentation as at the stations at Yakima, Wash., and Bentonville, Ark. At Yakima a large number of experiments were carried out by spraying apples in the laboratory and transferring newly hatched larvæ to them in order to obtain detailed information on the poisoning of the larvæ just hatched. In these tests the addition of a casein spreader to arsenate of lead improved the control.

At Bentonville, Ark., limited spraying experiments have been continued to clarify certain points in the control of this pest, which continues to be very destructive in that region in certain years. Fruit growers on the whole, however, are well acquainted with the most up-to-date methods of spraying, and the situation has greatly improved during the last few years.

#### INSECTICIDE INVESTIGATIONS

The investigation of miscellaneous insecticides has been continued at the laboratories in Washington and at the near-by field station at Silver Spring, Md. In addition, cooperation is in effect between the Washington laboratories and various field stations of this section in testing various new or improved preparations on a commercial scale. A thoroughgoing study of oil emulsions has been begun, and important progress has been made, especially toward increasing the stability of emulsions in hard water and lime-sulphur solutions. This complicated project will require several years for thorough work, but it is believed to be very important. The cooperative project on organic contact insecticides with the Insecticide and Fungicide Laboratory of the Bureau of Chemistry has been continued. Some of the chemical results of this cooperation have been published in the *Journal of the American Chemical Society* and a report is now in course of preparation on the insecticidal phase.

In cooperation with the Chemical Warfare Service, work is being continued with the so-called war gases and other materials developed at the Edgewood, Md., arsenal. A large number of these substances have been tested and a few found which give promise of value. A smoke candle for use in greenhouses has been developed and is being tested on a commercial scale. It would appear to have a distinct place in greenhouse insect control work.

Investigations at the Silver Spring, Md., laboratory, in cooperation with the Office of Truck Crop Insect Investigations of this bureau, have developed what appears to be a new contact insecticide which will in many instances be a suitable substitute for nicotine and will cost notably less. This insecticide mixes well with oil emulsions, and it is believed will make an excellent spray for the delayed dormant treatment for the simultaneous control of the San Jose scale and apple aphids.



## WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH

This work has been continued throughout the year under the direction of A. F. Burgess.

At the beginning of the fiscal year it was apparent that, with the funds available for field work, it would not be possible to carry through the plan of scouting and cleaning up a strip of territory surrounding the area known to be infested with the gipsy moth in Maine, New Hampshire, Vermont, Massachusetts, and Connecticut, and to examine a strip of towns some 20 miles wide extending from the Canadian border directly east of New York State line through the States of Vermont, Massachusetts, and Connecticut to Long Island Sound. A rough survey of this strip, together with the adjoining area in New York east of the Hudson River, indicated that on account of the somewhat level and moderately rolling country, and the sparse distribution of trees in a large portion of the area, it was more suitable to maintain as a clean area to prevent the spread of the gipsy moth westward, than any of the adjoining country toward the east.

The border work in Maine, New Hampshire, and northern Vermont was abandoned and all efforts concentrated on scouting a strip approximately 20 miles wide adjoining the New York State line. A contiguous strip in New York was to be scouted and treated by the conservation department of that State, under an initial State appropriation of \$150,000. The purpose of this work was to determine whether the insect had become established in this area and to clean up all infestations so that westward spread might be checked.

To the westward of Lake Champlain and the Hudson River are located the Adirondacks and other large mountainous areas linked with the Appalachian system where it would be practically impossible to carry on extensive scouting and clean-up operations, and if these areas should become generally infested rapid spread to the west and south would be inevitable.

The scouting work was continued throughout the fall and winter. Gipsy moth colonies were found in 10 new towns in Vermont and 4 in Connecticut. The conservation department in New York located colonies in 9 towns east of the Hudson River. The size of these colonies varied from a single egg cluster to 1,000 or more. In the

town of Alburgh, Vt., within a mile of the Canadian border, a small wooded area was found that was heavily infested. This was a direct threat not only to Canadian territory but to the Adirondack forest reservations in New York.

The cost of completing the scouting in the area handled by the bureau was greater than the original estimates and it was imperative that the infested area be thoroughly treated. It was also necessary that scouting and spraying work be conducted at Greenport and Patchogue on Long Island. To complete this necessary work, deficiency funds amounting to \$70,000 were made available April 2, 1923. As a result, the Long Island work was completed as planned, and all the infested areas were thoroughly treated and sprayed.

The season was abnormally late in New England and there was a heavy rainfall during June. On this account the spraying was not as effective as usual, although some of the areas were sprayed twice.

The work in New York progressed satisfactorily except that with the funds available it was impossible to scout all of the towns before spring. The colonies that were found were thoroughly treated and sprayed, and a decrease in the number of infestations is anticipated for the current year.

Heavy expenditures will be required during the coming year if this zone is to be finally established and maintained. The areas that it seems necessary to work intensively have been determined, and the costs can be estimated with reasonable accuracy. In the opinion of all experts who have given the project close study the opportunity is now available effectively to check the spread of this insect. It can not be done with inadequate funds, and if the amounts that are required are not available the attempt should be abandoned. Any course that promises less than adequate control will be expensive and unsatisfactory.

### FIELD WORK IN NEW JERSEY

The infested area in New Jersey has been reduced 50 square miles during the fiscal year and is now half the original size. Progress is also shown by the decreasing number of infestations and of the number of egg clusters that were found.

Difficult and expensive work yet remains to be done along the rivers flowing through the infested territory, and on the Watchung Ranges north of Boundbrook and Somerville. The

river banks in many towns are edged with birch, elm, and willow trees, many of which have large cavities or rough bark in which egg clusters of the insect may easily be concealed.

During the year trees on 500 acres of this territory have been cut and the brush and débris removed so that thorough work can hereafter be done at moderate cost. Substantial areas of similar character must be treated in the same way before the infestations in such sections can be eliminated. Infestations in tall trees and on the ridges which are heavily wooded have been especially difficult to deal with. Material progress has been made, but complete eradication of the insect will require more time in such areas than in the more sparsely wooded sections. The progress that has been made in New Jersey is very encouraging.

#### QUARANTINE AND INSPECTION WORK

During the year the Federal Horticultural Board has promulgated more rigid regulations in order to compel owners of nurseries and premises from which forest and quarry products are shipped to keep them free from gipsy-moth infestations. This has increased the work of the inspection force very materially. The extension of the quarantined area to include towns that were found infested during the previous year has added to the volume of work. During the fall of 1923 embargoes were laid by several States designed to prevent entry of Christmas trees and greens from New England. Later some of the embargoes were lifted, and the volume of these products offered for inspection was unusually heavy.

In the spring of 1924 most of these embargoes were removed by the States, and it is probable that the volume of shipments will be greater in the future.

The total number of shipments inspected and certified during the year was 106,224. In addition to this, 657 permits were issued.

#### FIELD AND LABORATORY RESEARCH WORK

Successful control of any insect pest requires constant experimental work in order to devise better methods and to take advantage of changed conditions as they develop. For several years the results of spraying on certain classes of foliage, particularly white oak and coniferous growth, have not been entirely satisfactory because the poison has failed to adhere firmly

to the foliage. The best stickers and spreaders that could be obtained were used, but the results were not entirely satisfactory if there was heavy rain during the spraying season. As a result of experiments with various substances, carried on during the past three years, it has been demonstrated this summer on large field plats that the addition of 1 quart of raw linseed oil, light-pressed fish oil, or corn oil to each 100 gallons of arsenate of lead spray caused the poison to adhere firmly to the foliage. Best results were secured with the linseed oil, but the other two mentioned are nearly as good. The fish oil is least expensive, but the cost of any of these materials is not prohibitive.

The effectiveness of spraying will be greatly increased by using one of these oils.

Very valuable data relative to retardation of growth of different species of trees due to defoliation are being secured and compiled, and many records of scientific value are being secured at the laboratory.

During the spring and summer three experts from the Melrose Highlands, Mass., laboratory have been engaged in studying the gipsy moth and its natural enemies in European countries, and temporary laboratories were used in Spain, Hungary, Serbia, Bulgaria, and Poland. Many other countries were visited, but the more important infestations were located in the countries named. A number of local entomologists were employed temporarily, and as a result nearly 90,000 parasites of several different species were shipped to America. These were cared for at the Melrose Highlands laboratory, and it is hoped that this will result in the establishment of several new enemies of the gipsy moth.

Aside from handling these importations, the laboratory has continued the work of colonizing parasites in the infested area in New England and New Jersey, and by means of check collections has determined the abundance of the different species that have been colonized heretofore. This work indicated that parasites and natural enemies of the gipsy moth were more abundant and effective this season in New England than ever before. The results were particularly noticeable in the area that has been infested the longest.

It is desirable that the parasitic and other experimental work be developed as rapidly as possible.

### GENERAL SUMMARY

The brown-tail moth continues to increase and cause damage in the sea-coast towns in New Hampshire and southwestern Maine. There are also some serious infested localities in the Merrimac Valley region in New Hampshire. Throughout the rest of the territory the insect is local and the damage slight.

The gipsy moth has been less abundant in the generally infested territory than for many years. A number of large defoliated areas were reported in Maine, central New Hampshire, and southern Massachusetts. In New Hampshire and Maine there was a rather high mortality of the eggs during the winter due to excessive cold. This condition was local rather than general, but in some localities was an important factor in reducing the increase of the species.

Hand-control methods, particularly spraying, have been an important factor in gipsy-moth reductions in many of the cities and towns.

In the country districts and wooded areas the beneficial results due to the parasites imported by the bureau can be easily seen. Because of these conditions the time was never more opportune to do effective clean-up work and to prevent the spread of the insect in the border territory. The work is organized so that effective results can be secured. The undertaking must be conducted on a large scale and can not succeed unless ample funds are available.

### CEREAL AND FORAGE INSECT INVESTIGATIONS

Prof. George A. Dean has been in charge of this section during the year.

#### EUROPEAN CORN BORER

The most important developments of the past year have been the appearance of the pest on the western end of Long Island in the borough of Brooklyn and the intensification of the infestation in the Ohio area at the western end of Lake Erie. In Long Island the infestation is located close to an important sweet corn producing section where a large part of the corn consumed in the New York market is grown. The principal danger lies in the possibility of infested sweet corn moving to the New York markets and thence possibly to other parts of the United States. With this danger in mind, a determined effort was made during May and June, 1924, to reduce this infestation to a mini-

mum by burning over the infested plants and weeds with the use of a specially designed oil-burning apparatus and by subsequently spraying the weed areas with arsenical weed killers in order to destroy such developing larvae as remained subsequent to the burning. It is hoped that the danger of spread has been largely reduced.

In order to meet the increasing abundance of the pest in northwestern Ohio and along the lake shore throughout that State, a comprehensive control campaign was worked out in co-operation with the Ohio State Extension and Farm Bureau organizations, resulting during April, 1924, in the conduct of a large scale clean-up campaign throughout the infested counties. Unfortunately, the weather during the period was most unfavorable, but much painstaking and thorough work was done which it is hoped will help to retard the invasion of the Corn Belt by this serious pest. Small infestations of the corn borer also developed in eastern Connecticut which were thoroughly cleaned up under the supervision of the State entomologist.

Progress has been made in the work of importing the insect parasites of the corn borer from its original home in southern Europe. One of the parasites liberated in the United States during 1922 has been found to have survived two winters in New England, and, as one of these was unusually severe, it is believed that it has become firmly established there. During the summer of 1924 colonies of this promising parasite were liberated in western New York and in Ohio, where conditions for its development are believed to be favorable. It is hoped that it may speedily become established there, although it is realized that several years must elapse before concrete results of its work can be expected. Additional parasites are constantly being found and studied in the parasite laboratory at Hyères, France, before attempts are made to introduce them into the United States.

#### THE ALFALFA WEEVIL

Although the alfalfa weevil has continued to spread, it is becoming apparent that an imported parasite is spreading practically as fast as the pest itself. Colonies of this parasite were liberated in Colorado in 1918 and in Nevada in 1921, and it is known to have become established in these States. The introduction of other important parasites is proceeding rapidly. Department Circular 301,

summarizing the parasite introduction work, was issued during April, 1924. The application of arsenates in spray for the control of the weevil has been practiced with success in Utah for several years, although this method has not been thoroughly perfected for use in Idaho and other States where the climate and altitude differ. As the procuring and hauling of water in connection with this method of control have involved a heavy item for labor in this irrigation region, it has seemed desirable to perfect a method of dusting which would eliminate this necessity. It is believed that such a method is now ready for application and a publication on this subject is being prepared.

There is great need of a thorough survey to determine the present distribution of the alfalfa weevil in the United States, but this work can not be done with the present limited resources.

#### GRASSHOPPERS

The burden borne by the wheat growers of the spring wheat belt during the period 1919-1923 was made doubly heavy by the occurrence of severe grasshopper outbreaks throughout most of this region. As a result of numerous requests for aid, Congress appropriated funds in 1921 requesting a special investigation of the grasshopper problem, and the bureau responded by placing an expert at Fargo, N. Dak. This station later was transferred to Billings, Mont. With the aid of the State agricultural organizations and experiment stations, great campaigns were waged against the pest in the Dakotas, Montana, Colorado, and Wyoming, with the result that millions of dollars in wheat and alfalfa were saved and at the present writing these outbreaks have largely subsided. The vigorous control efforts initiated by State and Federal entomologists are believed to have contributed importantly toward the suppression of these outbreaks.

An outbreak of grasshoppers in central and northern Texas which caused great anxiety in 1923 threatened to recur during June, 1924, but preparedness on the part of State extension workers, farmers, and Federal entomologists enabled them to gain control before serious damage occurred. A threatened outbreak in Oklahoma was also overcome.

#### SEED CHALCIS IN ALFALFA

The growing of Peruvian alfalfa seed in Yuma valley in Arizona and

California, which has become an important and profitable industry during recent years, has received a severe setback by the work of the alfalfa seed chalcis, which is a minute black wasp. This insect stings the developing pods and lays an egg in each seed. The resulting maggot devours the interior of the seed, entirely destroying its contents. Very heavy losses have resulted from the work of this pest in the Yuma valley and the seed growers asked Congress at its last session for aid in overcoming the pest. On July 1 the sum of \$5,000 became available and an expert was assigned, with headquarters at Yuma, to investigate this problem.

#### WIREWORMS

These subterranean insects usually have been considered as normally inhabiting grasslands and uncultivated soils, but in the Yakima Valley of Washington this has proved not to be the case. For several years past the injury to many crops by wireworms has been increasing, and the worst infestations observed in most cases have occurred in irrigated lands which had been longest under cultivation. The situation became so acute in 1923 that the growers in the Yakima Valley contributed immediate funds and requested aid from Congress in order to secure an investigation of the situation. On July 1, 1924, Federal funds became available for this work and an investigator was assigned to study the pest. The chief crops affected are potatoes, alfalfa, corn, nursery stock, and sugar beets. It is probable that several years' work will be required before the discovery of satisfactory control measures can be expected.

#### HESSIAN FLY

Although this well-known pest for several years past has been held in abeyance in the greater part of the winter wheat producing regions, it appeared abundantly during the summer and fall of 1923 in the extreme western and northwestern counties of Kansas and in northeastern Nebraska, where previously it had not been known to be injurious or even present. The wheat was heavily attacked by it in the fall and gravely threatened by its work. Fortunately, however, growing conditions stimulated the wheat in the spring and subsequent dry weather killed the eggs of the Hessian fly. At the present writing an excellent crop in this region is promised.



### SORGHUM MIDGE

The sorghum midge continues to be the limiting factor in the production of grain sorghum for seed in the interior of Texas. A method of control has been discovered and is being tested on a large scale previous to announcement for general application. This is a cultural method which it is believed will prove both safe and practical.

### STORED PRODUCT INSECT INVESTIGATIONS

Investigations in this section of the bureau work have continued under the leadership of Dr. E. A. Back.

The investigation of weevils attacking beans and cowpeas in California has been continued with gratifying results. Five papers containing data new to science have been prepared and submitted for publication. Experiments have definitely proved that the planting of weevily beans and cowpeas has no effect upon the infestation of the succeeding crop. This corrects a widespread and erroneous idea that the planting of weevily beans is the cause of a weevily bean crop.

On the other hand, it has been conclusively demonstrated by laboratory work and by field experimentation, including considerable acreages of commercially grown beans and cowpeas, that the infestation of maturing crops is due to the development of immense numbers of weevils in seeds held over from the preceding years and left neglected in storage near fields of growing beans. Over 350,000 four-spotted cowpea weevils (*Bruchus quadrimaculatus*) developed from one sack of 69 pounds of black-eyed cowpeas.

This work of the bureau has been followed by the bean growers with much approval and in one of the most important bean-growing sections has resulted in the formation of a bean-weevil committee, the purpose of which is to disseminate the new information secured by the department and to enforce recommendations which it feels certain will very greatly reduce the losses which bean growers are sustaining, and which have been steadily increasing with the continued culture of these leguminous crops.

With the passage of the grain standardization act the importance of insects in grain at grain terminals has been enormously increased inasmuch as the discovery of living weevils by the Federal inspectors reduces the grade, and frequently lessens the cash

value of a carload lot by \$250. Elevators have resorted to fumigation with carbon disulphide, at the expense of the shipper, to kill weevils and return grain to the grade to which it would belong were no living weevils found. This procedure was prohibited, except at New Orleans and Baltimore, early in 1922 by the action of the General Managers' Association of Chicago (representing the leading railway systems of the United States) because of the fire hazard associated with the use of carbon disulphide.

At the request of this association cooperative work was started between the Bureaus of Chemistry and Entomology with the result that over 100 volatile organic compounds have been tested. Thirty compounds have been found more toxic to the rice weevil than carbon disulphide, but fumigations of weevils in wheat in grain cars in railway yards under practical conditions left only two promising fumigants—ethyl formate and ethyl acetate. It was soon discovered that the commercial grades of ethyl acetate showed odoriferous constituents of low volatility that were carried through to the flour and the finished loaf. Further work has demonstrated that this objection to ethyl acetate is overcome if a pure grade is used. At present experiments with a 40–60 volume of pure ethyl acetate and carbon tetrachloride in amounts of 40 to 50 pounds per carload of grain indicate that a noninflammable, non-explosive, and effective fumigant has been found to displace carbon disulphide where fumigation with the latter can not be safely done.

Work with fumigants has progressed along other lines. A thorough study of the penetration of hydrocyanic-acid gas into sacked beans, peas, and cowpeas has demonstrated the practicability of this type of fumigation in warehouses where the use of large amounts of carbon disulphide gas might prove dangerous. The result of this work has already made hydrocyanic-acid gas fumigation the standard for warehouse control of bean and pea weevils where the seeds are sacked. Similar experiments have proved the futility of such fumigation for the control of the rice weevil, *Sitophilus oryza*, in sacked rice and corn.

Cooperative work with the Bureau of Animal Industry has proved that cured meats can be fumigated with hydrocyanic-acid gas safely and has led to a change in Federal inspection regulations permitting the use of this gas in meat establishments. The first



commercial establishment to be fumigated under the changed rulings was at Baltimore in the fall of 1920.

The ability of various food stuffs to absorb and retain hydrocyanic-acid gas differs greatly and has been investigated in cooperation with the Bureau of Chemistry. Few substances were found to contain more than 120 parts per million of hydrocyanic-acid gas after fumigation. While flour mills have been fumigated for years with hydrocyanic-acid gas, now other establishments such as candy factories, dried-fruit establishments, and warehouses containing a wide range of food-stuffs with few exceptions feel safe in using this gas.

The manufacture of liquid hydrocyanic acid has led during the past four years to its substitution in certain flour mills, tobacco warehouses, cereal establishments, and other storage plants for hydrocyanic-acid gas generated by the pot method. Tests have indicated that it is equally effective in fumigating inclosed spaces. Experiments attempting to find in liquefied hydrocyanic acid a suitable fumigant for large columns of grain in elevator bins by forcefully introducing the liquid into the grain by means of pumps and perforated tubings have not proved very promising.

The substitution of hydrocyanic-acid gas fumigation for the use of sprays, naphthalene, paradichlorobenzene, and beating in hide and skin warehouses for the control of the hide beetle, *Dermestes vulpinus*, has been a complete success. It has been demonstrated that such fumigation does not injure delicate skins or hides and has no effect upon the tanning process. One large manufacturer of kid leather has estimated that \$100 spent in hydrocyanic-acid gas fumigation solved his insect troubles as effectively as the expenditure of \$1,000 for labor and materials formerly required to accomplish the same result.

The development of vacuum fumigation in the dried-fruit industry has been one of the features of insect control in this industry during the past four years. In California certain of the larger establishments are now depending upon this type of fumigation.

A study of the effect of fumigation upon heating grain has demonstrated that when heating is the result of insect infestation the insects can be killed and the temperature of the grain reduced to normal by fumigation with hydrocyanic-acid gas or carbon disulphide. Even grain and beans heating to 103° F. have been reduced to nor-

mal temperatures by fumigation. Such reduction in temperature prevents the continued destruction of grain in cold weather when owners, not understanding the ability of insects to raise grain temperatures, believe they are enjoying protection due to insect inactivity resulting from temperatures of 50° F. or lower.

The value of commercial cold storage as a control for stored-product pests has been made the subject of investigation, and data regarding the time and temperature combinations necessary for the destruction of insects have been obtained. Data have been secured on the effect of various temperatures upon common pests of grain, cereal foods, flour, beans, peas, tobacco, and fabric pests such as clothes moths and carpet beetles. Important variations have been found in the resistance to cold by even closely related pests such as the rice weevil, *Sitophilus oryza*, so destructive to corn in the South, and the granary weevil, *Sitophilus granarius*.

In the case of the common clothes moth *Tineola biselliella*, it has been found that if the concern merely guarantees to protect articles during the period of storage, it is sufficient to maintain a temperature of about 40 to 45° F. At this range the eggs of the moth which are apt to be on fabrics or furs at time of storage will be killed if the period of storage is prolonged over six weeks. Experiments have shown that at 20 to 25° F. and at 25 to 30° F. clothes moth eggs are all killed in about three weeks; at 30 to 35° F. in 26 days; and at 35 to 40° F., in about one month. But the older, well-grown larvæ are very resistant. While these well-grown larvæ were killed in 67 days when subjected to an even temperature of 20 to 25° F., and in 93 days at 25 to 30° F., others held at temperatures ranging from 30 to 35° F. and 35 to 40° F. are still alive after over four months.

It has been demonstrated that the well-grown larvæ of clothes moths can withstand long periods of refrigeration at moderate temperatures. In one commercial establishment where the temperature range fluctuated from 24 to 48° F. but with the temperature mostly about 40° F., well-grown larvæ withstood refrigeration for from 6 to 14 months. Even larvæ that survived refrigeration for 14 months were normal, and upon being placed in a sufficiently high temperature for feeding, resumed activity and transformed normally as though their life had not been prolonged by a forced hibernat-

ing period. These facts are important, for they explain why patrons at times have found living robust insects in articles several days after removal from 4 to 5 months in cold storage. If a fairly even temperature around 40° F. has been maintained, such a discovery is to be expected and is no reflection upon the storage firm.

Investigation of fabric pests has received much attention during the past three years. Farmers' Bulletins dealing with clothes moths (No. 1353) and carpet beetles (No. 1346) have been published. Studies of the webbing clothes moth, *Tineola biselliella*, and the carpet beetles *Attagenus piccus* and *Anthrenus fasciatus* are being brought to a close and material has been secured for technical bulletins dealing with these three pests.

An investigation has been completed, in cooperation with the Bureau of Plant Industry, which determined that chests of red cedar, *Juniperus virginiana*, can be depended upon as protectors against clothes moth attack when only very young clothes moth larvae are present at the time the fabric is placed in the chest. When properly prepared according to recommendations of the department, clothing can be safeguarded in red cedar chests. Experiments have also determined that chests of Eucalyptus and California redwood and closets lined with red cedar wood and in constant use are of no value as protectors against fabric pests; that the oils of Eucalyptus and pine are of little or no value, but that the oils of red cedar and camphor, used to impregnate chest linings, etc., have a decided value.

It has been established beyond question that naphthalene and paradichlorobenzene are among the most dependable substances that can be used in tight containers for protection against all stages of the clothes moth, thus definitely establishing the status of naphthalene when properly used and adding a new control in the form of paradichlorobenzene.

An investigation of insects attacking cured meats has been started during the past four years but has been temporarily discontinued. According to a 1921 estimate, Federal meat inspectors annually condemn \$1,000,000 worth of meat of all kinds on account of insect injury. The cheese skipper, *Piophilæ casei*, is a prime pest and occasions great losses to the meat trade and to the farmers who cure small amounts of meat for home consumption. A thorough study of the biol-

ogy of the *Piophilæ* fly has established the fact that during hot weather the female, which lives only 5 to 8 days, may lay as many as 500 eggs, and that the insect may pass through two generations a month. Over 52,000 skippers were reared from a 21-pound ham, over 1,200 insects leaving the ham on certain days. These facts indicate the tremendous possibilities for increase in and about meat establishments. A study of the ham beetle, *Necrobia rufipes*, has demonstrated that adult beetles may live more than 14 months, that adults may deposit as many as 2,100 eggs, and that the life cycle from egg to adult may be completed in as few as 30 days. In the control of meat pests prevention of infestation plays an important part. Papers containing information regarding the biology and control of meat pests have been prepared.

The past four years have witnessed a very severe outbreak of the Angoumois grain moth, *Sitotroga cerealella*, throughout the eastern wheat regions. Special investigation of the pest has been conducted during the past two years and has developed new facts concerning biology. The infestation of wheat in the field at time of crop maturity has been found to be much greater than was formerly believed, thus emphasizing the importance of prompt harvesting and threshing. During 1922 it was found that in a badly infested region Angoumois grain moth infestation was reduced to less than 2 per cent by prompt harvesting, threshing, and proper storage, whereas on neighboring farms when threshing was greatly delayed, infestation ran as high as 80 to 90 per cent.

The investigation of the rice weevil has continued during the last four years. The biological work conducted in Florida has been transferred to Washington. In southern Georgia a special effort has been made to determine what relation may exist between storage conditions and field infestations and whether the latter can be improved by the intelligent application of remedial measures in storage. Surveys of field infestations before harvest have been made and studied in connection with the location of farm granaries.

#### TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS

Investigations of tropical and subtropical fruit insects have been carried out as heretofore under the direction of Dr. A. L. Quaintance.

### CITRUS FRUIT INSECTS IN FLORIDA

At the Orlando, Fla., station work on the control of scale insects and whiteflies has been continued on both a laboratory and a commercial scale, especial attention being given to oil emulsions. One formula under investigation, namely, the so-called kaolin emulsion, has proved to have distinct merit and will be treated in a forthcoming article in the Journal of Agricultural Research as a joint contribution from this bureau and the Bureau of Plant Industry.

Early in the year an aphid outbreak occurred in the Florida citrus belt, being first noted about Tampa. It soon spread northeastward, reaching Orlando and other points. Such an epidemic was unknown to the growers and the habits of the insect made control operations difficult. The spring growth was heavily damaged in the southwestern portion of the area. Study proved the insect to be *Aphis spiraeicola* Patch, a species not before recorded on orange. It evidently had occurred in the orange belt on *Spiraea* and had adopted the orange as an alternate host. Some unusual condition had resulted in the enormous multiplication of a relatively unknown species. A study of climatic conditions seemed to give the key to the situation. In the epidemic area, February and March were very unusual—cool and wet—ideal aphid conditions. These months marked the peak of the epidemic. By June the weather had returned to the average and the June growth escaped. The future status of the insect will probably depend upon seasonal conditions in the citrus belt. This aphid is a new enemy of the orange that is capable of doing enormous damage.

### CITRUS THRIPS

Investigations of the citrus thrips in California have been continued at the bureau's laboratory at Lindsay in cooperation with the Tulare County Citrus Growers' Exchange. The thrips was not very abundant during the spring of 1923, and experimental work in orchards did not permit of positive conclusions as to the relative value of the treatments given. Beginning with the spring of 1924, a considerable amount of spraying was done in cooperation with various growers, covering 86 acres. Spraying operations were divided between applications in winter, applications in spring, and applications during both winter and spring. The biologic investigations

during the spring of 1924 resulted in the discovery of several important facts. It appears that the citrus thrips does not overwinter in trash under trees as formerly held. The insect passes the winter in the egg stage in the tenderest growth of the preceding fall. One new winter host, in addition to citrus, has been discovered, namely the pepper-tree. Several additional hosts have been added to the list and the fact noted that citrus trees continue throughout the active season as the chief supporting host of the thrips, there apparently being no marked exodus of the insect to other plants. A thorough search during the spring of the native plants failed to reveal the existence of a single native host of the citrus thrips.

### FRUIT FLIES IN HAWAII

Studies of fruit flies in Hawaii have been continued, including inspection and certification work, in cooperation with the Federal Horticultural Board. Some 2,100 inspections were made, and an idea of the scope of this work may be gained from the following figures:

Packages rejected as unfit for shipment	315
Shipping permits issued to transportation companies	1, 423
Bunches of bananas passed for shipment	216, 823
Crates of pineapples passed for shipment	13, 470
Crates of taro passed for shipment	5, 142
Crates of coconuts passed for shipment	861
Crates of ginger root passed for shipment	26
Crates of lily root passed for shipment	983

Careful attention must also be given to inspection of baggage of travelers, and this work involved the inspection of 737 pieces for passengers arriving at Honolulu from foreign ports, and leaving Honolulu for other United States ports. Beginning April 1, 1924, and until the close of the fiscal year, 832 pieces of baggage belonging to passengers leaving Honolulu for the United States were inspected and sealed. This service has proved very popular with all concerned and greatly reduces the risk of introduction of the fruit fly or other dangerous pests to the mainland in travelers' baggage.

As heretofore, records of parasitism of the Mediterranean fruit fly by its four parasites have been continued, as well as of the degree of infestation of different fruits by the insect. These records would indicate that infestation of the different host fruits

was about the same as during several years previous. Parasitism by all four species during the year 1922 was 47.2 per cent and, in 1923, 43.2 per cent, showing a decrease of 4 per cent in parasitism of all larvæ under observation. Comparing the effectiveness of the individual species in 1922 and 1923, striking differences are shown. Following are the percentages of parasitism by each species during those years: *Opius humilis*, 1922, 4.6, 1923, 4.1, difference, 0.5; *Diachasma tryoni*, 1922, 33.7, 1923, 12.2, decrease, 21.5; *Diachasma fulwayi*, 1922, 2.5, 1923, 1.6, decrease, 0.9; *Tetrastichus giffardianus*, 1922, 6.4, 1923, 25.3, increase, 18.9. The cause of the fall in parasitism by *D. tryoni* has not yet been determined. The large increase in parasitism by *T. giffardianus* is due to the fact that a very high parasitism by this insect was obtained from a large number of tropical almonds collected during August, September, and October from an acre in the Punahou covering about four city blocks and where, for some unknown reason, the parasite had been able to increase rapidly.

Considerable work has been done to determine the effect of cold-storage temperatures on larvæ of the Mediterranean fruit fly. Records have been secured on 80,524 larvæ of different stages which were developing in several different kinds of fruits. These fruits, containing the larvæ, were held for varying lengths of time at temperatures ranging from 32° to 40° F., when they were removed and observations made on the number of living and dead larvæ. The results of these experiments were generally the same as previously reported by the bureau. In South Africa experimenters have found live fruit fly larvæ in peaches which had been in cold storage for six weeks at a mean temperature of 33.97°. Thousands of larvæ in apples experimented with at the Honolulu station were held in cold storage at 33 to 34° and one larva was found living after 18 days' refrigeration, which is the longest record of survival at that temperature. The low resistance to cold shown by fruit fly larvæ in Hawaii is probably due to the very uniform temperature existing, since they are not subject to such variations in temperature as occur in deciduous fruit-growing sections in South Africa. Observations have been continued on the four weevils attacking the Algaroba bean and considerable progress made in a study of their

life history and the efficiency of six weevil parasites.

#### FRUIT FLIES, CANAL ZONE

At the Panama Canal station, investigations have been continued of fruit flies and other insect pests of the more important fruits, such as avocado, mango, pineapple, papaya, sour-sop, banana, etc. The insects receiving major attention were the avocado weevil, the avocado fruit moth, avocado leaf moths, citrus black fly, a coconut palm caterpillar, fruit moths attacking sour sop and cherimola, and the papaya and other fruit flies. Careful inspections were made of various fruit orchards, town sites, etc., in order to keep thoroughly in touch with local insect pests, and especially to determine whether introductions have been made in view of the large amount of traffic from all parts of the world through the canal. The need of an adequate quarantine for the Canal Zone is very apparent if it is to be maintained free of foreign pests, as well as to protect the continental United States.

In cooperation with the Office of Forest Insect Investigations, important progress has been made in the study of termites occurring in the Canal Zone and surrounding regions. Extensive experiments have been carried out in developing methods of preventing their injuries, which are quite serious under the climatic conditions there obtaining.

#### CAMPBOR SCALE

Distinct progress has been made in the investigation of the biology and seasonal history of the camphor scale. Further observations on host plants of this insect indicate that it is a rather general feeder. Observations have been made on the effect of the cold weather during the winter of 1923-24 on this insect, when the thermometer reached about 19° F., and the results will shortly be published. Considerable time has been spent in tracing shipments of nursery stock and other plants from the infested region which might have carried the pest. This work has been fairly thorough and it appears that the scale has not become established at any new points. Experiments in fumigation of the scale with hydrocyanic-acid gas at various strengths and temperatures, necessary in the movement of nursery and florist stock in the New Orleans district, have been continued



and results put in effect by local plant growers. Progress has been made in perfecting an oil spray suitable for camphor scale operations.

#### GREENHOUSE INSECTS

Studies of greenhouse insects have been continued as in former years and distinct progress has been made in this field. Life-history studies of the larger bulb fly have been started and experiments conducted in the disinfection of bulbs from this insect. The larvæ appear to be very resistant to vacuum fumigation with carbon disulphide at the rate of 4 and 10 pounds per 1,000 cubic feet of space. Additional information has been secured on the biology of the cyclamen mite and control experiments begun, which include the testing of nicotine, sulphur, oil emulsions, soap sprays, pyrethrum, hydrocyanic-acid gas, carbon disulphide, etc.

The Cattleya fly has continued to receive attention and additional facts concerning its life history and habits have been learned. Fumigation with hydrocyanic-acid gas has not thus far proved of value against this insect in any of its stages. Experiments are in progress with nicotine dusts and with other insecticides to develop methods of control.

The infestation by the tip moth of certain pine seedlings grown at Halsey, Nebr., led to the undertaking of experiments in the disinfection of seedlings with hydrocyanic-acid gas at various strengths, and treated plants have been returned to Halsey for planting and further observation.

Investigations in the general field of fumigation have included the testing of various dosages and exposures on a variety of plants, such as orchids and various bulbs. In tests with calcium cyanide it has been found that the killing power of this chemical for certain greenhouse aphids compares favorably with equivalent dosages of sodium cyanide. Under greenhouse conditions it was found that overnight fumigation at the rate of one-fourth ounce of calcium cyanide to 1,000 cubic feet of space gave 100 per cent kill of three species of aphids, though later tests in which the chemical was used at the rate of one-half ounce resulted in severe burning of many varieties of plants by reason, it is believed, of the extremely high humidity at the time.

Considerable attention is also being given to the general subject of insecticides from the greenhouse standpoint.

In this work experiments have been carried out with nicotine sulphate dusts, free nicotine dusts, oil emulsions, and the like.

#### ECONOMIC SCALE INSECTS

Work on this project has been largely taxonomic. A large amount of identification has been made for bureau and other workers, and gratifying progress has been made in classifying and better arranging the collection. A preliminary census of the present scale insect collection indicates that there are approximately 3,000 described species, of which some 1,800 have been identified. Some 208 genera are represented out of a total of 250 genera currently recognized. Special attention has been given to the preparation of good microscopic mounts of all identified species still unmounted and of all those represented by mounts inadequate for critical study. Two papers dealing with special collections of scale insects, one from the Galapagos Islands, the other from the Canal Zone, have been prepared and the first published. A paper on the subfamily Ortheziinae has been rewritten after the inclusion of much additional matter.

#### VEGETABLE AND TRUCK-CROP INSECT INVESTIGATIONS

Work in this section has been continued, under the direction of J. E. Graf. The Mexican bean beetle and the sweet-potato weevil have received the greatest amount of attention as in the preceding year. Additional tests of remedies for the control of the Mexican bean beetle have been most encouraging. Unusually good progress has been made in the eradication experiments on the sweet-potato weevil in various localities in Florida, Georgia, Alabama, and Mississippi.

#### THE MEXICAN BEAN BEETLE

The Mexican bean beetle has continued its rapid spread. As in previous years, the greatest extension of the infested area has been in a northeasterly direction, the beetle being found at the end of last summer in Columbus, Ohio. During the late summer of 1923 and the early summer of 1924, the spread continued until now the insect has almost reached Lake Erie, has been found in West Virginia near the Pennsylvania boundary, and has extended its range to the south and east to a greater extent than usual in Georgia, North Carolina,



and South Carolina. The Thomasville, Ga., infestation, which had not spread to any extent in three years, led to the belief that the insect would not thrive under the humid conditions and low altitudes found in the coastal plain areas. During the present summer, however, the boundaries of this infestation have been greatly extended and the insect has been more injurious to beans than in any previous season. It appears, on the basis of this year's observations, that our hopes that the insect would not prove a major pest in the coastal plain may be unfounded.

Biological work on the insect has been continued and has shown only minor changes in the insect's habits. Since 1921, the insect is appearing later each year, and in 1924 it issued from hibernation 30 days later than it did in 1921. The insect apparently has not yet completed the process of adapting itself to the changed climatic conditions which are found in the humid Southeast and it is impossible to predict its behavior.

Numerous requests for assistance continued to be received from Kentucky, Virginia, West Virginia, North Carolina, South Carolina, Alabama, and Ohio, and according to the correspondents the beetle is living up to its reputation as the worst insect enemy of beans. Tests with arsenicals and other insecticides are being continued at the main laboratory in Alabama and at other points in Tennessee. In the latter State experiments were conducted in cooperation with some of the canners and it was found that the use of magnesium arsenate as a spray has given very successful control on large areas. This remedy is probably best adapted for the use of growers since most of the other arsenicals may, under certain conditions, cause some injury to the bean plants. The use of magnesium and calcium arsenates, both as sprays and dusts, has given the same successful results as in previous years.

A serious effort was made during the summer of 1923 to establish the Mexican tachinid fly parasite *Paradexodes epilachnae* in this country, but apparently these experiments have all failed. In the case of the parasites which were kept in Alabama, the flies issued and perished during the late fall after the bean beetle ceased to breed. Shipments of the tachinid puparia were sent to Melrose Highlands, Mass., and Estancia, N. Mex., for hibernation, as it was felt

that the low temperature at these places would keep the insect dormant throughout the winter. No flies have issued from any of these shipments, however, and it is presumed that they are all dead. From the parasite investigations undertaken thus far, it appears that barometric pressure may have a very important effect on the development. In view of the rapid spread of the Mexican bean beetle, it will undoubtedly be necessary to continue attempts to colonize this promising parasite in the United States, and in order best to accomplish this end it will be necessary to station a man in Mexico, in order to work out in detail the biology of the parasite and its host under Mexican conditions.

#### SWEET-POTATO WEEVIL

The sweet-potato weevil eradication work has been continued successfully in southern Mississippi, Alabama, and two of the eradication areas in Florida. The principal test project for the eradication methods under the Bureau of Entomology is the Baker-Charlton County area in northeastern Florida and southern Georgia. In this area the infestation covers parts of two counties and at the beginning of the work it included 196 infested farms, with 68 additional doubtful farms. Active eradication measures were begun in 1919, and by 1920 every farm in the entire area was under the supervision of Government and State inspectors. Since the beginning of the work 250 farms have been infested at one time or another. The greatest number of infestations was found at the time the work was initiated and has decreased considerably in each succeeding year, so that by 1923 only one farm was known to be infested at the time of the summer inspections, and at the time of the fall inspection the weevil could not be found anywhere within this area. No weevils were found in the area during the summer inspection of 1924. While two farms are still listed as "dangerous and suspicious properties," it is believed that the eradication of the insect in this test area will be attained. It will be necessary to maintain a careful patrol within this area for about two years after the last weevil has been found.

The importance of this eradication experiment can not be measured alone by the size of the affected area or by the quantity of sweet potatoes it pro-

duces. The infested zone is near Jacksonville, Fla., the principal railroad center of the State and the point through which practically all interstate shipments originating from Florida must pass. Had the infestation spread and included this point, it is quite probable that it would have been impossible to ship any sweet potatoes from Florida to other States on account of the State quarantines now in force. Aside from the fact that this experiment has proved definitely that cultural methods for the eradication of this insect are entirely successful, it has also shown that growers by careful and inexpensive farm practices may greatly reduce the degree of infestation on their own farms.

In Mississippi the work has been hampered to some extent by a lack of adequate personnel, but with the assistance of the unusually cold winter, the infestations have all been greatly reduced in intensity and considerable progress has been made in the eradication areas. In Alabama the infestation, which was most threatening to the commercial sweet-potato producing zone, has apparently been eradicated and the only farms known to be infested at present do not constitute an immediate threat to the production of sweet potatoes in southern Alabama.

Biological studies have been continued in both southern Mississippi and Florida and data of interest and importance have been added during the past year.

#### OTHER INSECTS INJURIOUS TO PEAS AND BEANS

Work on the pea aphid has been continued in both Wisconsin and California. In both places cooperative investigations with the canners and State officials have demonstrated the possibility of controlling the pea aphid under conditions of average infestation. Experiments have also been conducted to show the effect of a light attack of the pea aphid on the quality of the resulting crop, and it has been definitely proved that infestations which were hitherto considered noninjurious very definitely lower the quality of the peas. While a study of the biology and ecology of the pea aphid has been continued as formerly, the main effort has been directed toward control. The construction of the proper machinery for the application of insecticides has been one of the important problems. This

work consisted principally of the development of proper booms for distributing the insecticides under all conditions. Calcium cyanide dust has shown some control value, but it also has some toxic effect on the plants, and the investigations have not yet reached the point where it may be recommended for general farm use. Under average conditions, nicotine dust is the safest and most effective direct remedy for this insect, but since it must be used in high concentrations, the work of proper control is expensive. A machine for mechanically collecting the aphids, known as an aphidozer, has been devised during the past season and preliminary experiments have indicated that it may be of great value. This method of treatment has the advantage of being inexpensive, since the first cost of the machine, together with the labor in connection with the application, is the only expense involved.

#### INSECTS INJURIOUS TO CUCURBITS

**The striped cucumber beetle.**—Additional reports during the present season have definitely shown that the nicotine dust remedy which has been recommended by the Bureau of Entomology has been successfully used by growers. Calcium cyanide has shown a high toxicity against this insect, but unfortunately it also injures the plants under certain conditions and it is therefore impossible to give it an unqualified recommendation at the present time.

**Melon and pickle worms.**—Work on the melon and pickle worms in North Carolina has shown that these insects do not always appear together as had been previously supposed. Since one of them may be controlled, this discovery alone may lead to the development of a practical method of control for the early summer form.

**Melon aphid.**—Tests with nicotine dust have again shown that this method of treatment is much superior to the application of nicotine as a spray.

#### POTATO AND TOMATO INSECTS

**Potato leafhopper.**—During the late summer of 1923 additional experiments in the control of the potato leafhopper were conducted in Wisconsin, which definitely showed that Bordeaux spray, properly applied, will give very satisfactory control.

**Australian tomato weevil.**—Biological studies on the new Australian tomato weevil, which recently made its ap-

pearance in southern Mississippi, have resulted in working out the general arrangement of generations of this insect in the United States. Control operations have been greatly hampered by the cold weather of the past winter, which also greatly reduced the numbers of this insect in the field.

**Seed-corn maggot on potatoes.**—The seed-corn maggot appeared as a major pest of seed potatoes in North Carolina during the season of 1923. Only control measures were conducted on this insect and preliminary tests indicated that mercury bichloride used as a dip for the seed potatoes has a definite effect in repelling the insect and preventing injury.

#### INSECTS INJURIOUS TO CABBAGE AND RELATED PLANTS

**Cabbage maggot.**—Further tests with remedies against the cabbage maggot have shown that the mercury bichloride treatment is much superior to the older protective methods of paper disks, etc.

**Turnip flea-beetle.**—Nicotine dust was used as a remedy for the turnip flea-beetle on cabbage and related crops in Louisiana, and very satisfactory control by this method was obtained in the preliminary tests.

#### ONION INSECTS

**Onion maggot.**—Experiments are also being conducted in Wisconsin against the onion maggot, and the Oregon method of control by using cull sets for the attraction of the fly is being given large-scale tests. In this case also the preliminary results indicate that this method is much more satisfactory than any of the control methods used heretofore.

#### SUGAR-BEET INSECTS

Work on the sugar-beet leafhopper has been continued in California and additional points on the relationship of this leafhopper to the abundance of curly-top have been discovered. The principal work on this insect is the determination of the relation of wild hosts of the leafhopper to resultant curly-top in the sugar-beet fields. Experiments with disease-resistant sugar beets are being continued and a strain of plants has been found which shows some resistance to curly-top. No information on the possible utility of this resistant strain has been obtained.

#### WIREWORM INVESTIGATIONS

Studies on the control of cultivated land wireworms are being conducted in Washington and California. Both soil fumigants and baits have received numerous tests and the present results indicate that a combination treatment, using baits to attract the insects and following this with an application of a soil fumigant, will give an effective and relatively cheap control.

#### BERRY INSECTS

Investigations of the leaf-roller weevil, and root-aphis affecting strawberries are being continued as rapidly as the personnel will permit. A combination of cultural and insecticidal control for the weevil has given favorable results in North Carolina.

#### INSECTICIDE INVESTIGATIONS

Experiments with new and promising insecticides are under way in both Maryland and California. In the latter State a complete study of nicotine dusts as regards their composition, volatility, and effectiveness is being conducted, and tests are being made on numerous insects affecting general truck crops. At the Maryland laboratory tests of a new and promising insecticide are being conducted in cooperation with the Division of Fruit Insect Investigations. At the present time a promising and cheap contact insecticide has been developed and further tests with this material are now being undertaken.

#### GENERAL TRUCK-CROP INSECTS

**Bean leaf-beetle.**—The status of certain insects as carriers of plant diseases is being studied in Louisiana, and during the past season it has been definitely proved that the bean leaf-beetle (*Cerotoma trifurcata*) is a positive transmitter of cowpea mosaic. At the same place observations have been made on the effect of leafhoppers as regards the various types of injury caused by the different species. It has been found that some wild plants act as temporary hosts for certain species of leafhoppers and that on these plants the injuries sometimes closely resemble those which are produced on cultivated plants. This study will lead to a better understanding of the seasonal movements of some of the injurious insects and the temporary hosts involved.

**Corn earworm on tomatoes.**—Observations made on an outbreak of the corn earworm on tomatoes in South Carolina indicate that poisoned bait is worthy of further attention as a control measure for this insect. The control of the corn earworm on tomatoes by arsenical sprays has been an uncertain remedy in most of the experiments to date and the promising preliminary results obtained by the bait indicate that it may be possible to devise a more satisfactory remedy for this troublesome pest.

**Mole-crickets.**—Further tests in the control of mole-crickets have shown that the poisoned bait will give successful control when it is properly made and applied.

**Pepper weevil.**—During the summer of 1923 the pepper weevil was found to be present in several isolated areas in southern California and caused considerable damage in many instances. Preliminary observations were made on the biology of this pest.

#### SOUTHERN FIELD-CROP INSECT INVESTIGATIONS

Dr. W. D. Hunter has been in charge of these investigations, as formerly.

##### COTTON BOLL WEEVIL

Further progress has been made in the development and modification of the calcium arsenate method of weevil control, as well as in the study of other methods. Somewhat less attention was devoted to the results secured by farmers, since the use of calcium arsenate is now becoming sufficiently general to make the results more or less a matter of local and seasonal conditions. Approximately 30,000,000 pounds of calcium arsenate were used by the farmers in 1923, and a survey of results, while approximate, indicates that probably 300,000 bales of cotton were saved from the weevil by this poisoning. A more intensive study of the results of 524 farmers scattered throughout the Cotton Belt shows an average increase in yield of 396 pounds of seed cotton per acre resulting from the poisoning.

The cost of poisoning was reduced slightly by improvements in machinery, requiring less poison, and also by further experience which has been acquired by the farmers. It was found that the average number of applications for the full season's treatment was 3.4, as compared with 3.8 for the preceding season, and that the average quantity of calcium arsenate per acre per application was 5.4

pounds, as contrasted with 6.2 pounds in 1922. The prospects were very favorable for exceedingly wide-spread dusting in the cotton-growing season of 1924, and the sales until spring indicated a consumption of from 50,000,000 to 60,000,000 pounds of calcium arsenate. However, the cold weather during January, 1924, caused an exceedingly low emergence of weevils, and this was followed in the States from Alabama westward by a phenomenal drought during the period when the weevils are ordinarily multiplying most rapidly. As a result, except under purely local and outstanding favorable conditions, weevil injury has been almost totally absent from this territory, and there has been little or no necessity for poisoning. In the Southeastern States, particularly Georgia and South Carolina, a more nearly normal rainfall has prevailed, and weevil poisoning has progressed somewhat as usual.

The activities extending back several years, looking toward an increase in the arsenic supply, have finally borne fruit to the point where there is apparently an ample supply of arsenic in sight for any normal demand which can be expected, and there seems no reason why this supply can not be further expanded as demand increases.

During 1923 a great deal of attention was devoted to comparisons of different methods of weevil control under various conditions. The annual series of studies on extent of weevil damage, as measured in comparison with plats in which the weevil was thoroughly controlled by dusting, was taken as a basis for contrast with other methods. It was found that in these straight-dusted plats there was an average increase of 226 pounds of seed cotton per acre, at a cost of \$4.95, making a net profit at current prices of \$18.05 per acre. The homemade molasses mixture showed a cost of \$3.30 per acre for the season's treatment, and an increase of 86 pounds of seed cotton, producing a net profit of \$5.47.

The Florida method of boll-weevil control was studied with particular interest in Louisiana, Texas, Georgia, and South Carolina, and it was found in averaging the tests at all of these points that the total cost per acre was \$2.95, and the average increase was 36 pounds of seed cotton per acre, making a net profit of 78 cents per acre. Three of the most prominent proprietary mixtures which were being most widely used by the farmers were tested in similar comparisons.



All of these showed a net loss from their use, ranging from \$2.55 to \$10.98 per acre.

A very important event was the general survey of weevil-control methods and results at the different experiment stations, conducted by a special committee of the Southern agricultural workers, and the presentation of these figures at the annual meeting during the winter months. All records available were thoroughly studied and analyzed by this committee. From this study the most authentic recommendations to date were settled upon and standardized for use by the farmers, and suggestions for further experimental work were outlined. These suggestions are being carried out in the experiments of the bureau during 1924.

The laboratory at Florence, S. C., conducted in cooperation with the South Carolina State Experiment Station, has been continued with a particular effort toward securing contrasting records on all points where the different environmental conditions of the Southeastern States may produce any modification in results, as compared with the conditions at Tallulah, La. Various control measures have been studied in their relationship to southeastern conditions, and a special biological organization has been perfected for the purpose of a complete study of weevil biology under these new conditions. The agronomic organization, maintained by South Carolina at this station, affords a very unusual opportunity for studying those features of weevil control which involve a combination of both entomological and agronomic problems.

The most important progress has been made in the effort to locate an attractor for the weevil which, if found, may be used in some way toward control. This study is based on the fact that the weevil attacks only the cotton plant, and in all probability is attracted to this plant by some odor peculiar to it. This study is being carried on in cooperation with the Bureau of Chemistry of the Department of Agriculture, and the chemists assigned by them, after distilling many tons of cotton plants to secure the volatile chemicals present, have been working on this material in the laboratory with very promising results. Certain materials have already been isolated which give definite indications of slight attraction for the weevil, and extensive laboratory and field tests are under way with these

chemicals in the effort to locate a distinctively attractive mixture and dilution of these.

Special attention has been devoted to the relationship between the control of the boll weevil and other cotton insects. The application of calcium arsenate to cotton for weevil control of course affects many other insects, and it has been found necessary to make a complete study of this effect on the entire insect population of the plants. It has been found that decided secondary benefits arise from the control of numerous miscellaneous feeders. Particular attention has been devoted to a study of the increase in aphid infestation, which sometimes accompanies the use of poison. It has been found that this phenomenon has apparently a decided relationship to climatic conditions and also to the seasonal incidence of the poison applications. Judging from the information so far, it seems quite probable that the increase in aphid can usually be avoided by proper modification in the poisoning schedule which will not interfere with the successful control of the weevil. At the same time, a study is being made of the exact amount of damage resulting from the aphid infestation, and of the best methods of control when it actually occurs. Numerous contact insecticides have been tested, and the most effective settled upon.

The hibernation and emergence studies have been continued and the peculiar winter conditions of 1923-24, followed by the peculiar climatic conditions of the summer of 1924, have furnished an interesting series of records to round out the observations on this subject.

The studies on airplane dusting have been continued more extensively than in the past. A great deal of attention has been devoted to the mechanical features of the problem, and numerous devices for distributing the poison from the plane have been developed and perfected. It has been found that as airplanes possessing different flying characteristics are employed, it is necessary to develop different equipment, and in this way at least five distinct types of dusting equipment for the planes have been produced.

During 1923 weevil control with the airplanes was undertaken on two entire plantations, totaling about 3,000 acres, and as a very heavy outbreak of the leafworm followed on these same properties, the control of this insect was likewise included. A large



volume of figures on all phases of airplane operation for insect control were secured, and the net result of these was the definite showing that the airplane may be used to distribute poison efficiently, effectively, and profitably for the control of the weevil and leaf-worm as contrasted with the results of dusting with ordinary ground machinery. At the same time it was also found that the military airplane, which has been used solely, was not suitable for this work, and a number of airplane manufacturers were interested in the subject of developing special planes for insecticide distribution, which would be more efficient and safer than the military types which have been employed. Several of these have now been built and are being studied and developed, while the commercial possibilities have extended to the point where quite a few thousand acres were dusted commercially by airplanes during 1924 and extensive plans are under way for more widespread use of this method in the future.

The airplane dusting has led to many interesting and important developments in connection with the other lines of work, and has particularly furnished several definite leads, indicating the possibility of daylight poisoning with ordinary dusting machinery. It seems that at least a considerable portion of this effect is due to the electrical charging of particles of this dust which is produced by the plane, and a very extensive project is under way involving cooperation with the Bureau of Public Roads on the mechanical side and the Bureau of Standards on the electrical side thoroughly to work out the principles involved and their possible application to commercial operation.

New types of ground-dusting machines have been built, with special reference to some of the new principles of dusting, discovered from airplane operation, and what is apparently one of the most efficient dusting machines so far produced has passed through a considerable portion of the experimental stage, and it is hoped that it will soon be ready for commercial construction. This is the first machine which shows definite promise of being a satisfactory daylight-dusting machine. At the same time numerous other types and modifications of the ordinary grade of dusting machines have been studied, modified, and improved, all of which is constantly improving the supply of

dusting machinery on the market for use of the farmers.

Extensive studies have been continued on all phases of weevil toxicology, including development of new poisons, and particularly a thorough study of the different types of calcium arsenate in relation to their effectiveness. This is being correlated with methods of manufacture, and several new methods have been studied. It is quite obvious that when this study is complete a much more efficient calcium arsenate will be available, and, furthermore, that it will be possible to eliminate materials of low efficiency which have been responsible for erratic results by the farmers in the past. Included in this study have been many suggestions originating outside the department. In fact, nearly 200 such suggested methods of weevil control have been under test in the single season.

Numerous reports of damage to game have resulted from the extensive use of calcium arsenate, and the Bureau of Biological Survey has been cooperating in an effort to determine if there is any basis for these reports. So far there seems to be no basis whatever, and there is apparently little or no chance that the ordinary operation of dusting will result in serious injury to insectivorous birds or other game.

#### TOBACCO INSECTS

In the dark-tobacco belt plant beds that have been used for more than one season very commonly develop severe infestations of the larvæ of the green June beetle. During the year methods of control have been perfected.

The tobacco flea-beetle has been more than usually injurious both upon newly-set plants and on full-grown plants. Farmers' Bulletin 1425 describes the control measures perfected during the year.

Various species of wireworms have been found attacking tobacco plants in as many as 18 of the Burley tobacco counties, in the vicinity of Lexington, Ky. The loss due to missing and stunted plants is as high as 10 to 12 per cent in some fields and is conservatively estimated at 5 per cent in many fields. The total loss runs into the hundreds of thousands of dollars. From 5 to 7 per cent of this injury has been prevented by a trap bait and at a cost of less than 1 per cent of the value of the crop.

A 1-wheel, 2-row mule duster, devised by field employees of this bureau

last year, is now being sold commercially and seems to fill the need for better dusting machinery more economically than any previous duster.

The budworm continues to be a serious pest of tobacco in the more southern of the tobacco-growing States. During the year at the Quincy, Fla., laboratory an economical method of control was worked out for the type of tobacco not grown under artificial shade.

#### SUGARCANE AND RICE INSECTS

Various observations and experiments during the year have added to our knowledge of sugarcane and rice insects. Two parasites of the sugarcane moth borer were found in Mexico, and one was brought into Texas in some numbers. The Cuban parasite released some years ago in Louisiana was found again at various plantations. The native egg parasite was observed to become active earlier in the season than was supposed, and it is evident that it is of much value.

In cooperation with the Bureau of Agricultural Economics the damage to sugarcane in Louisiana due to the sugarcane moth borer was estimated, the Bureau of Agricultural Economics obtaining information by means of questionnaires mailed to sugar planters, and the Bureau of Entomology estimating on data from its own field examinations. These figures, obtained independently, were found to agree to a remarkable extent. The loss in 1922 was taken as 16.5 per cent, in 1923 as 23 per cent, with a normal loss of 18.5 per cent.

A mimeographed circular, which was reprinted in the sugar journals, was afterward issued. This gave the best available suggestions for the control of the moth borer and appealed for the cooperation of planters to try them out. Partly as a result of this circular it has been possible to arrange for a number of plantation experiments on borer control. The results of this work should be of great benefit.

The investigation in cooperation with the Mississippi Plant Board on a pink borer injurious to sugarcane and corn was completed. The insect is of a new genus and new species, and has been described by Dr. H. G. Dyar as *Meropleon cosmion*. It is believed, as a result of our investigation, that, though rare, this borer is a native insect, and owing to its slow development it is not to be feared as a new pest.

Wireworms were found to be very injurious in the poorly drained lands

on one plantation in Louisiana, and life-history studies and control experiments were started.

At Cairo, Ga., some information was gained on the control of ants in sugarcane fields with the object of thereby controlling the sugarcane mealybug. More experiments were started. A farmer who had adopted our recommendations as to obtaining uninfested seed cane and planting it at some distance from infested cane met with complete success, obtaining a field of perfectly clean cane.

The life history and methods of controlling rice insects are being studied. It was found that the sugarcane moth borer is more injurious to rice than is the rice stalk-borer. It was found possible to destroy 100 per cent of the newly hatched borers of both species with calcium arsenate. Grazing was found of benefit on cut rice fields, the tramping of the animals destroying the borers hibernating in the rice stubble.

A new braconid parasite was found attacking larvæ of both the rice stalk-borer and the sugarcane moth borer in rice.

Efforts were made to ascertain the actual damage due to rice insects. Hibernation studies were also commenced, and some information gained as to the hibernation of the rice water weevil and the rice stink-bug.

#### INSECTS AFFECTING THE HEALTH OF MAN AND ANIMALS

##### SCREWWORM

Investigations of this important pest of livestock in the Southwest have been carried on in cooperation with the Bureau of Chemistry and the Texas Experiment Station as heretofore. The discovery that benzol is admirably adapted for the destruction of the larvæ in wounds has been a distinct forward step. The use of this larvicide is now being adopted by many stock raisers with better effects on the animal tissue and uniformly high killing power against the maggots, and at a cost far below chloroform or other good larvicides. Satisfactory progress has been made in the study of repellents for application to animals. The pine tar oil-furfural mixture is meeting the needs of stockmen in this direction but it is hoped to develop something which will be more healing to wounds and even more lasting as a fly repellent. Chloropierin in low dilution in mineral oil, which was first tested this year, is a very promising repellent dressing.

### CATTLE GRUBS

Studies of this destructive pest of cattle have been continued throughout the year. Control methods by the application of washes and ointments to the backs of the infested cattle have been further perfected and are now considered fairly satisfactory for use on dairy and farm animals.

The large amount of information on the cattle grubs accumulated during the last several years has been prepared for publication. These data will serve as a basis for control work which is contemplated by several States.

### POULTRY PARASITES

Further studies have been made on the sticktight flea and a large series of tests have been made with various materials fed to fowls with a view of killing or repelling external parasites. These tests were made not with any strong hope of securing beneficial results, but to gain much-needed information as to the effect of such materials on the parasites and fowls. Hundreds of thousands of dollars are being spent by poultrymen and farmers for proprietary compounds which are shown by these tests to be valueless.

### MALARIA MOSQUITOES

Experiments were conducted during 1923 to determine the possibilities of controlling *Anopheles* breeding in extensive swamp areas by means of dry insecticides distributed by airplanes. Army planes which had been equipped for cotton dusting were used and Paris green diluted with an inert carrier was employed as the insecticide. Breeding areas offering a variety of conditions, ranging from comparatively open lakes to heavily overgrown-swamp areas were treated, and it was found that when the dust mixture was properly distributed a large proportion of the larvæ could be easily and quickly killed over large areas.

An investigation was also begun in 1923 on the chemotropism of *Anopheles*, with a view of finding substances which were attractive or repellent to them.

The study of the host preference of malaria mosquitoes, which has been carried out in cooperation with the School of Hygiene of Johns Hopkins University, was continued during the year. A definite preference was shown as between certain species of animals

and an even more decided preference as between individuals of the same species.

### INSECTS AFFECTING FOREST RESOURCES AND SHADE TREES

Dr. F. C. Craighead has been in charge of this important section during the year.

A tendency toward sharper demarcation in certain forest insect investigations has been gradually developing in recent years. To meet this situation and more efficiently handle the increasing demands for assistance, it will be necessary to build up stronger organizations in the field. Already the western bark-beetle investigations and the associated cooperative control work have necessitated this step. Consequently the several field stations of the Pacific Coast States and Rocky Mountain region have been consolidated into a regional organization under the leadership of J. M. Miller, with Dr. H. E. Burke assisting in the direction of the technical investigations. The advantages of this step are already evident, allowing more direct contact between field station officers and foresters of the respective districts and permitting more prompt examination of beetle-infested areas and execution of control work.

The establishment of closer contacts with the Forest Service experiment stations is also imperative but can not be put into execution until more funds are available. A demand exists that forest entomologists be associated with these station personnels to study certain types of injurious insects that can be controlled only through the adoption of proper forestry practices. One step has been taken in this direction. Through a cooperative arrangement with the Minnesota Agricultural Experiment Station and the Lake States Forest Service Experiment Station, the services of Dr. S. A. Graham, of the former institution, have been secured to represent the Division of Forest Insects of the Bureau of Entomology. Investigations of two important forest insects have been undertaken. As soon as possible entomologists will be stationed at each of the Forest Service experiment stations.

Bark-beetle control projects have continued to demand much attention and have formed the major part of the activities of this division. Less time has been available for other investigations, and efforts along these

lines have been concentrated on problems of greatest economic importance. The more important results are as follows:

#### **THE SOUTHERN OREGON - NORTHERN CALIFORNIA CONTROL PROJECT**

The close of the past field season witnessed the successful reduction of the western pine beetle on this project to a status where the normal growth of the mature forest will more than compensate for the losses occasioned by this insect. This means an annual saving of 50,000,000 or more board feet of timber valued at over \$200,000.

This project, which was started in 1921, undertook to control the pine beetle over an area of 1,270,000 acres where the losses in the last 10 years had reached over a billion board feet of merchantable yellow pine valued at more than \$3,600,000. The operations were carried out by the Forest Service of this department, the Indian Service of the Department of the Interior, and private timber owners represented by the Klamath Forest Protective Association, under the advice and supervision of the Bureau of Entomology.

During the two and a half years of control 24,648 infested trees containing 27,976,900 board feet were treated at a total cost of \$112,818.59, divided about equally between the private timber owners and Federal Government. The cost of the work averaged \$4.57 per tree, \$4.03 per thousand board feet, or 35 cents per acre treated.

#### **THE ANTELOPE CONTROL PROJECT**

The past year marked the completion of the 3-year program on this project. On an area of 52,000 acres a reduction of 80 per cent of the infestation was secured—a saving of over 9,500,000 board feet, worth \$32,000. Not only was this outbreak successfully controlled, but this was actually accomplished at no extra cost. This was due to utilization of the treated trees and satisfactorily demonstrated the practicability of combining control work with logging operations.

#### **THE KAIBAB CONTROL PROJECT**

During the control seasons of 1922 and 1923, \$8,000 and \$10,000, respectively, were spent in fighting this outbreak of the Black Hills beetle. This work was concentrated on the larger centers of infestation where locally good results were obtained, but the outbreak over the area as a whole has developed at such a phenomenal

rate that these measures were wholly inadequate. Already nearly 750,000,000 feet of timber have been killed. During the 1924 control season the Forest Service expended nearly \$50,000 with the object of treating all infested trees over the entire area. The National Park Service is also cooperating on this project.

#### **NORTHERN ROCKY MOUNTAIN CONTROL PROJECTS**

Several successful control projects were conducted in Idaho and Montana. On the Helena National Forest one year's work resulted in a reduction of 94 per cent of the infestation in a stand of lodgepole pine.

#### **EXPERIMENTAL CONTROL PROJECTS AND BARKBEETLE INVESTIGATIONS**

Several control projects of a purely experimental nature have been conducted. The Forest Service has given its approval of these and has cooperated with personnel and funds.

#### **THE SAN JOAQUIN PROJECT**

This project, planned to test the possibility of maintaining effective control after the major operation, has been carried through its fourth season on an area of 40,000 acres in the Sierra National Forest. Although another season is necessary to bring the work to a satisfactory conclusion, preliminary results indicate that the methods employed were effective in holding down losses during a period when natural influences favored an increase. The advantages of applying control measures to infestations of even an endemic character appear to be warranted, as the cost of the work about equaled the stumpage value of timber that was saved.

#### **THE FIGUEROA PROJECT**

This project, located near Los Olivos, Calif., was instituted to determine the possibility of entirely eliminating bark-beetle infestation from a small isolated tract of yellow pine on the Santa Barbara National Forest. This project has been under way for two seasons. Because of the high recreational values involved, success will be of economic as well as experimental value.

#### **BARK-BEETLE INFESTATION ON THE CALIFORNIA NATIONAL FOREST**

It is worth while to record a most phenomenal increase and decline in a bark-beetle epidemic on the California National Forest. During the sea-



son of 1922 over 67,000,000 feet of timber were destroyed, equivalent to 2.2 per cent of the entire stand. This was an increase of 700 per cent over the infestation of the previous year. During 1923 the epidemic almost completely died out, representing a decrease of 93 per cent. Efforts are being made to determine the causal factors involved in this remarkable condition.

#### THE ROGUE RIVER PROJECT

A more detailed knowledge of the epidemiology of the western pine beetle and the contributing factors will be of great practical importance in control and may as well afford a possibility of predicting outbreaks. Since 1914 surveys to determine the annual losses on the Rogue River drainage have been conducted with this objective in view. During the 9-year period 5.58 per cent of the stand has been killed; the annual losses have shown a marked periodicity varying from one-tenth to 1 to 2 per cent of the stand. Incidental to this statistical study, a large amount of detailed information on the bionomics of this beetle has been secured, pertaining principally to the interrelation of outbreaks and climatic conditions, the ratio of the number of progeny to attacking beetles, the effect of predators on the developing broods, the character of trees attacked, the attractive influence of forest fires, and the development of the broods in trap trees, felled trees, and slash.

#### DEFOLIATING INSECTS

The spruce budworm has not been reported in epidemic proportions in either the New England or Lake States during the past year, yet some timber is still slowly dying as the result of earlier defoliation. Recent studies indicate a decided correlation between the rate of growth of the trees and mortality from the defoliation. This result may be of much practical benefit in preventing future injury through proper forest management. The outbreaks in Wyoming and Idaho are still progressing, and reports indicate an outbreak on the Carson National Forest in Arizona. Continued studies and additional important observations have been made on several other defoliating insects—the Pandora moth in Oregon and California, the white pine butterfly in Montana, and the jack pine sawfly in Minnesota. The last-named insect is seriously threatening large areas of

jack pine in Minnesota. Some progress has been made in studying the effects of defoliation on the growth of the annual rings, indicating that it is possible to determine the dates of recent or past outbreaks from the effects produced in the growth of these rings.

#### THE SOUTHERN PINE BEETLE

The threatened outbreak reported last year developed into epidemic proportions in many States from Virginia south to eastern Texas. The losses in Virginia were particularly heavy as well as in certain portions of Mississippi. Additional information has been obtained pertaining to the susceptibility of certain types of pine forests. The lumber associations are much concerned over the losses sustained and have given much assistance in disseminating to their members practical information on control. It was impossible to conduct any demonstration in control by bureau representatives. Fewer reports of damage were received in the early summer of 1924, though it is still too soon to determine if this outbreak has actually died out.

#### INTERRELATION OF SLASH AND BARK-BEETLE OUTBREAKS

Considerable time has been devoted to investigations pertaining to the entomological aspects of slash from logging operations in the Western States. The results of these experiments will be published in the near future, showing that the slash from logging operations is not effective in furthering outbreaks of the species of *Dendroctonus* bark-beetles. In fact, breeding of the beetles in this class of material tends to reduce their numbers.

#### INSECTS AFFECTING FOREST PRODUCTS

Experimental work has been continued during the past year in perfecting methods of prevention of insect damage to crude and finished forest products. These pertained chiefly to practices involving seasoning and water submerging and to the use of chemical sprays. Several large companies have followed this bureau's recommendations, adopting certain alterations in handling their green logs which eliminated all insect injury and resulted in a big saving annually. Additional results have been secured demonstrating that usual kiln schedules for seasoning ash and oak stock will kill *Lyctus* powder-post beetle stages in the wood. Through coopera-



tion of the Division of Deciduous Fruit Insect Investigations, a series of experiments has been undertaken in Panama to determine the efficiency of certain wood preservatives and chemicals in preventing injury by white ants in the Tropics. Similar experiments conducted in Virginia, for example, might not give dependable results for the more southern climates.

#### **INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS**

The demand for information concerning insects of this class continued to increase during the past year to such an extent that little time has been available for conducting investigations. Nearly 2,000 inquiries were answered from Washington. In California attention has been concentrated on insect problems pertaining to public parks and recreational areas. This has developed into a rather specialized field requiring methods of control less intensive than those for city trees, though greater expenditures are permissible than under forest conditions.

#### **BEE CULTURE INVESTIGATIONS**

The work of the Bee Culture Laboratory, under the supervision of Dr. E. F. Phillips, has been continued along the same general lines as formerly. The laboratory and experimental apiary of the bureau are located at Somerset, Md., near Washington.

#### **BEHAVIOR OF BEES**

The investigation of the responses of colony activity to changes in external temperature, humidity, and other factors, begun during the summer of 1921, has been continued. No additional experimental data have been collected since May, 1923, but the time since then has been spent in computing the amount of correlation existing between changes in colony weight, hour by hour, with changes in external factors. A paper has been prepared for publication recording the results of the work on changes in colony weight. Work has been begun on the calculation of the correlations of temperatures of various portions of the hive with external temperature and other changes. The work on colony-weight changes for the first time gives reliable information on the extent of the influences of various climatic factors on the honey crop and shows that a study of the physiology

of nectar secretion in plants does not completely explain the abundance or absence of nectar in plants which usually secrete it.

The investigation of the amount of brood at weekly intervals throughout the brood-rearing season is being continued with only one colony during the present season, this being a colony of special interest in clearing up certain points on which sufficient data were not obtained in earlier years. The calculations from these data have required much time and care, but the work is nearing completion. From the data obtained it has been found possible to determine the changes in egg-laying rate of queens at various times of the year, the total colony population, as well as the number of bees available for gathering nectar, the percentage of empty cells left by the queens as they pass over the brood combs, and the total number of eggs laid in a single season. The migrations of the queen to various parts of the brood-nest have also been determined. The influence of external temperature on the egg-laying rate and the differences in egg-laying of queens of various ages are now being determined. During the year a paper was prepared for publication outside the department on the egg-laying rate of queens.

The work on the responses of bees to light has been completed and a paper prepared for publication. It is found that bees do not respond invariably to light but that they are capable of modifying their behavior when kept under controlled conditions. The paper by Doctor Lineburg on larval feeding has been published as a part of Department Bulletin 1222, and additional observations on the behavior of worker bees when feeding larvæ have been made during the present season, the results of which will be published later.

Observations have been made on the number of molts of bee larvæ. It is found that during the period of larval development the larva molts four times, at intervals of about 24 hours.

#### **PHYSIOLOGY OF BEES**

The work on the availability of various carbohydrates as food by adult bees has been continued and the results are almost ready for publication. A similar line of work is now being carried out on the availability of these carbohydrates for worker larvæ. So far there is no information available regarding the di-

gestion of the bee larva, and it is important to determine whether the bee larva is as limited in its utilization of the more complex carbohydrates as is the adult bee. It has been found possible to use bee larvæ experimentally outside of the hive, since they will live and continue development in an incubator on the foods used experimentally, provided the food can be utilized.

The work being done on the changes in the oenocytes according to the age of the worker has been continued and observations have been made of the oenocytes during larval and pupal life, for the purpose of determining whether the oenocytes of the adult bee are the same as those observed in earlier stages. The function of these cells and their significance to the bee are not yet clear.

The revision of R. E. Snodgrass's *Anatomy and Physiology of the Honeybee*, mentioned in the last report, has now been completed and will shortly be published in book form outside the department. The paper by Doctors Nelson and Sturtevant on the rate of growth of the larva has been published during the year as a part of Department Bulletin 1222. A paper on the uses of pollen by bees has been prepared by Dr. E. F. Phillips during the year.

The study of the colors of American honeys, in cooperation with the Bureau of Agricultural Economics, has been continued during the present season. Following the determinations of the transmission of lights of various wave lengths through the samples of honeys collected for this study, an effort has been made to obtain materials which will retain their colors permanently and which may be used in the making of a color grader for honeys. This has been found exceedingly difficult, for the transmission of light through honeys is effected not only by the coloring materials in the honeys but also by the degree of turbidity. It is also found that the turbidity of honeys changes considerably on standing, which complicates the making of proper graders. By taking a more or less arbitrary standard turbidity, it is possible to construct a grader which looks like honey and which gives promise of permanency, so that probably this problem is almost solved. The materials used in making graders will now be subjected to severe tests for permanency, and, if they prove satisfactory, directions will be published for their manufacture. The work on the materials in

honeys which produce the variation in color has been completed and will be published shortly.

The laboratory during the year has furnished material for a study of the constituents of royal jelly (the food of queen larvæ) other than the usually recognized chemical materials. It has also furnished material for a study of the rate of mitotic cell division in the rapidly growing worker larva. These two investigations are being conducted by workers outside the laboratory.

#### DISEASES OF BEES

The paper on the distribution of the Isle of Wight disease in other countries has been published as Department Circular 287. Since its appearance, additional records of much interest have been received. The mite *Acarapis woodi*, which causes this disease, has been found in Czechoslovakia and Austria, and additional information indicates that the report of its presence in South Africa was incorrect. The only additional embargo on the importation of adult bees which has appeared during the year is that prohibiting the importation of bees to the island of Jersey from England.

The law of August 31, 1922, prohibiting the importation of adult bees into the United States, makes provision for the importation of adult bees for scientific or experimental purposes. Adult bees imported for such purposes must be shipped to the United States Department of Agriculture for examination, and if found free of all diseases of adult bees may then be sent to the person for whom they were imported. Under this provision of the law, the department has, during the past year, made importations for a number of persons who were able to qualify under the regulations. A total of 61 queenbees were imported and in none of the shipments were any mites found which cause the Isle of Wight disease. A considerable number of the shipments were found heavily infected with *Nosema apis*, a protozoan parasite of the alimentary tract of the adult bee, but, since the presence of this parasite is permitted in importations, it has not been necessary to destroy any shipments on that account. These *Nosema*-infected bees were almost all from the Province of Carniola. The reshipment of these queens to various parts of the country has been unusually fortunate, since only two queenbees have been lost

after leaving the bureau, these being queens reshipped after a long voyage from abroad which reached the bureau in bad condition. Under the regulations adopted, adult bees may be imported from Canada without restriction.

The examination of diseased or abnormal adult bees from all parts of the United States has been continued, this being done chiefly by L. M. Bertholf. During the fiscal year samples of adult bees from the United States to the number of 177 were examined but, as in previous years, no samples were obtained from any parts of the United States in which the mite causing the Isle of Wight disease was found. This work has also been continued during the remainder of the summer of 1924 and so far none of the bee samples have contained this mite. The results of the examinations for 1921 and 1922 have been published in detail in Department Circulars 218 and 287.

There recently appeared a paper by an American beekeeper giving a method whereby combs infected with American foulbrood may be disinfected and again used. This method has attracted much attention in all parts of the world, since the saving of infected combs is a great help in the control of this disease. The attention given this work has necessitated a considerable amount of investigation of the disinfecting value of various substances, as well as of various liquids to be used as carriers of the disinfectant. This work has been done by Dr. A. P. Sturtevant. It is found that it is not difficult to kill the spores of the causative organism if they can once be reached, but to obtain a liquid which serves as a carrier to penetrate the cappings of the cells containing the dead larval remains is exceedingly difficult. Beekeepers in all parts of the country have been experimenting along this line for the past year and a considerable number of them have submitted to the office samples of combs which have been subjected to various disinfecting solutions, in order that the efficiency of their methods may be checked by cultures.

Experience in the use of disinfectants under apiary conditions shows that there is need for some change in the composition of the solution, or in the method of use, which will simplify the practice, greatly lessen the cost of application, and especially make the results more positive and unvarying. The investigation now being conducted

has these aims in view and, while it is not yet possible to announce definite methods, much progress has been made. An outbreak of American foulbrood in the vicinity of Washington and in the bureau apiary during the present season has provided an abundance of material for experimentation.

During the past fiscal year samples of diseased brood have again been examined for beekeepers and apiary inspectors, a total of 966 samples having been submitted.

A study of the fungi found in the alimentary tract of the adult bee has been begun, a considerable number of species having so far been found. The significance of these fungi is still unknown, and the work will be continued.

The bee-louse, *Braula coeca*, was found some time ago in a series of apiaries in northern Maryland and also in Pennsylvania, where it seems not to be causing much if any loss.

#### BEEKEEPING REGIONS IN THE UNITED STATES

Lack of funds has prevented active work on this subject, although there is great need for more specific recommendations for beekeeping practice in the varying beekeeping regions of the country. A paper has been prepared for publication outside the department on beekeeping in the Northwest. Information is constantly being collected on the methods of beekeeping suitable to various parts of the country, and it is planned in the near future to begin more active work of this kind.

#### DEMONSTRATIONS IN BEEKEEPING

The work on this project has been still further reduced during the past year and at the close of the fiscal year all cooperative work with the various States was discontinued. The demonstration work begun just previous to the entrance of the United States into the World War was greatly expanded during the war. Later the work has gradually been transferred to the several States in which work was done, and it is gratifying that in almost all such States the work has been continued at State expense, indicating that the need for such work is becoming generally recognized.

Under this project the office aims to maintain contact with the beekeepers of the country, and in the absence of field employees it is necessary for the office staff to attend certain of the more important gatherings of beekeepers in various parts

of the country. This serves the purpose not only of letting the beekeepers know what the office is doing in their behalf but also keeps the men of the office in close touch with the needs of the beekeeping industry.

#### MISCELLANEOUS ACTIVITIES

The correspondence of the office, chiefly handled by E. L. Sechrist, continues to be heavy. Although the present low price of honey has discouraged the beekeepers in all parts of the country, they still continue to take a deep interest in their work and to submit their inquiries to this office. The development of beekeeping work in the various States has doubtless decreased the inquiries direct to this office, but there has been no appreciable falling off in the correspondence since the war.

#### INSECT PEST SURVEY

J. A. Hyslop has continued in charge of this branch of the bureau's work since its inception in March, 1921. The survey has now functioned three years and three months and is constantly becoming more intimately associated with the entomological activities throughout the country.

The cooperation of the several States in supplying the survey with data on general and unusual insect conditions is now so well organized that the survey is in a position to report at any time on the entomological situation prevailing in any part of the United States, and by its cooperative agreement with the Dominion of Canada's Insect Pest Survey Service is also closely in touch with the situation throughout that country.

In recognition of the survey's position it has been requested to participate in the meetings of the Crop Estimate Board, to serve that board in an advisory capacity on the status of insect pests affecting the crops upon which this board issues estimates.

During 1923 the survey completed volume 3 of its monthly bulletins in 8 numbers which consisted of 338 pages of text material and an index of 38 pages. Volume 4, Nos. 1 to 4,

was also issued during the last fiscal year, comprising 149 pages of text material.

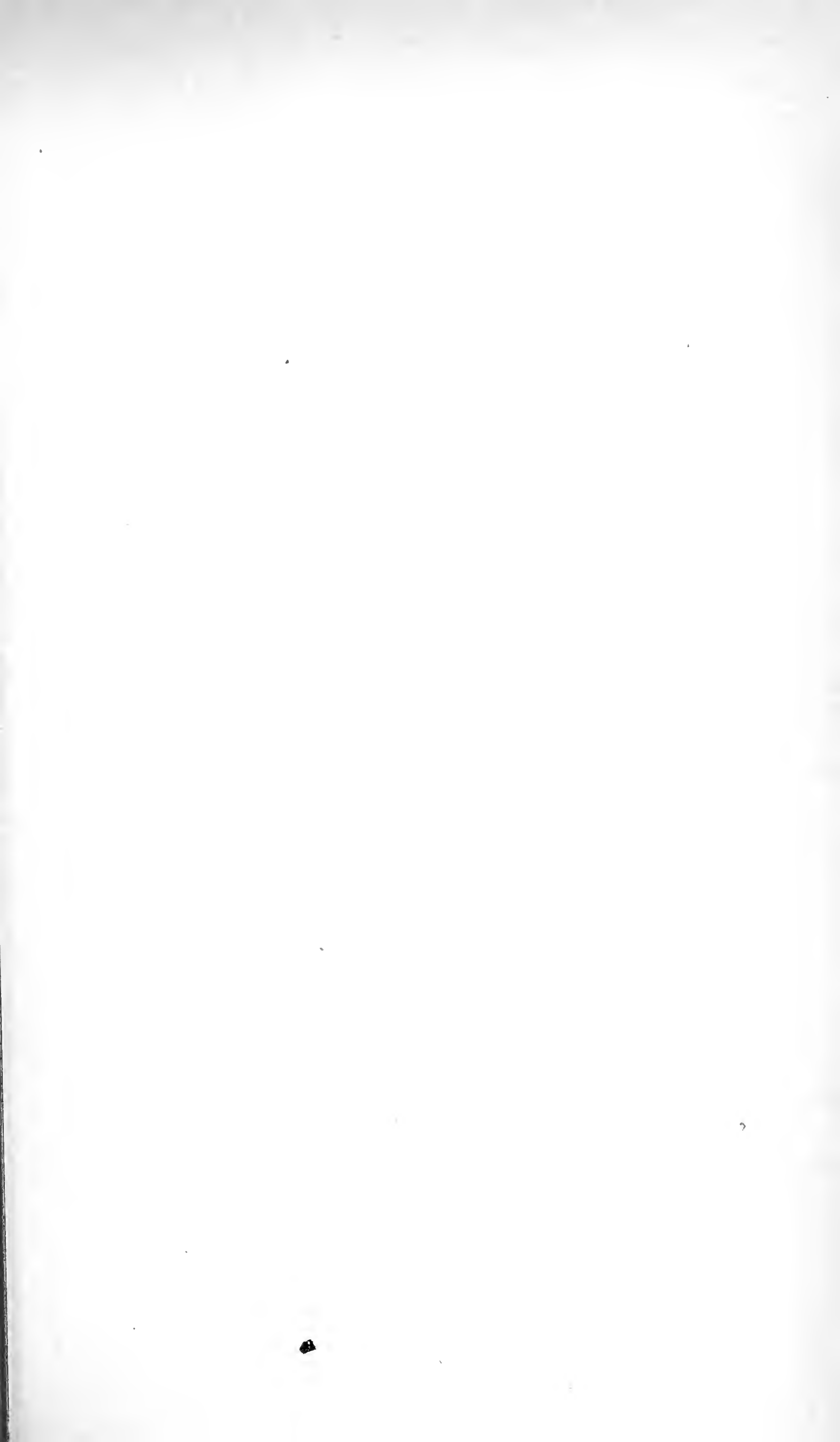
The special reports on other urgent matters were issued during the year from Nos. 26 to 35 and emergency matter was handled in the form of telegraphic reports. These latter assumed a rather important phase during the current year in keeping the entomological agencies in the Cotton Belt in close touch with the northward movement of the cotton leafworm. As the season was unusually late, the presence of this pest was decidedly more significant than in the average year, and favorable comments on this service have been received from several sources.

During the past year the survey occupied a considerable part of the time at the annual meeting of the American Association of Economic Entomologists, held during the Christmas holidays in Cincinnati. This time was devoted to a symposium on "Methods of Estimating Insect Abundance and Damage." Many constructive papers were presented and the meeting resulted in the appointment by the association of a committee to prepare a report for the next meeting, recommending to the association a system of codifying methods of estimating insect abundance and damage.

The preparation of the index of common names applied to insects in this country, which the survey prepared for the association, resulted in the appointment of three members of the bureau to act as part of the association's permanent committee on common names. The committee presented at the Cincinnati meeting a very comprehensive list, which, after certain revisions, will be published during the coming year and should materially facilitate the use of uniform common names in this country.

The survey now has in manuscript form a technical paper on the correlation of climatic conditions with the abundance of the chinch bug throughout that part of the United States where this pest was a serious factor from the years 1870 to 1920, inclusive. This paper should be completed during the coming year.





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